apc

Nov 2015
Issue 421

YOUR EXPERT   GUIDE TO TODAY'S TECH

CARD GAMES

NVIDIA vs AMD
THE BEST GPU OPTIONS FOR EVERY BUDGET

EYE POPPIN'

NEXT-GEN
GAMING NOW

THE FUTURE OF PC GAMING IS HERE: GO BEYOND 1080P WITH SUPER-FAST SCREENS, 4K & MORE!

HOTTEST TECH REVIEWED

- Netgear 'Wave 2' 802.11ac router
- Win 10 portables
- Sub-$150 Android phones
- Star Wars BB-8

LEVEL-UP YOUR GREY MATTER

- Linux-powered VPN made easy
- Master Windows 10 on tablet
- Hack the Mac notification center

CHILL OUT YOUR PC

The complete beginner's guide to water cooling: everything you need to know

THE REAL PRICE OF A FREE WEB

APC's editor argues that you should think before you block web advertising en-masse.

Apple's incorporation of ad-blocking in iOS 9 has made headlines all over the web. Apple's not doing the ad blocking directly — it's simply letting third-party developers make apps to add the functionality to Safari. And while it may initially seem for the users benefit, at the very least it's a two-pronged initiative — critically, it lets Apple attack one of Google's major sources of income. But the tech giant's tacit approval of ad-blocking won't just harm Google — it could ultimately change the web as we know it.

Ad-blocking certainly isn't a cut-and-dry issue and web publishers aren't entirely blameless in bringing this 'ad apocalypse' down upon themselves. If web ads weren't at least a little annoying, people would be more willing to tolerate them. And there are certainly legitimate reasons to block them — the most understandable being that you don't like being tracked and targeted by advertisers, or that web ads make for a slower web experience on the whole.

That said, web ads are arguably better than they were — pop ups are all but gone (barring websites that throw up a full-screen splash begging you to join their newsletter) and those sites that do use video ads at least generally mute them. But whether you like or loathe them, the web media needs ads to survive — at least if it's going to largely remain free.

Apple is in something of a privileged position in this debate because it makes most of its money from selling products, with a bit on the side coming from apps, games, music, and movies. But advertising is one of the big reasons that a lot of the websites and services we take for granted for free. And it even extends beyond the web — it's why you can go out and get a Chromecast for $40 and that Google can afford to give Android away for free to any hardware developer that wants to use it.

And even the developers of iOS 9 ad-blocking apps are in two minds about the morality of it. The developer of Peace — which shot straight to the top of the App Store when iOS 9 was released — actually pulled the app and issued refunds after realising the impact it could have on the web as a whole. Other ad-blockers have, of course, already rushed in to fill its place.

The crux of the issue is that, if online media outlets and services aren't making enough money to support themselves from advertising, they'll have to seek out other ways of making money. For publishers, that likely means sites will have to beg for money using crowdfunding platforms like Patreon (**www. patreon.com**) or take a more hard-line approach by building paywalls.

If you value the free web as it is, I'd think carefully before blocking the web ads that power it. Or at the very least, you should whitelist your favourite sites. ∎

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EMBRACING THE RANDOM

HOW GAMES HAVE LEARNED FROM ART, MUSIC AND MATHS – AND HOW THE WORLD MIGHT LEARN FROM GAMES. DANIEL GRILIOPOULOS

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> "It's awesomely frustrating to power up in the morning and your operating system has been "improved" and nothing bloody works anymore." Epinions, p14.

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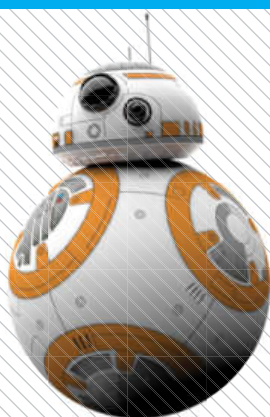
Apple goes after the Surface Pro 3

Does the iPad Pro have what it takes to dethrone Microsoft's slate?

It's been a long time coming, but Apple has finally announced the newest member of the iPad family — the iPad Pro is Apple's entry into the slate tablet market, and is certainly the most advanced iPad the Cupertino company has produced yet, but can this iOS powered device compete with the Windows 10 enabled Surface Pro 3?

Pitched at designers and other professionals, the iPad Pro boasts an eye-opening 12.9-inch display with a 2,732 x 2,048 resolution and is capable of showing a staggering 5.6 million pixels. It will come equipped with Apple's third generation 64-bit processor, the A9X chip, which Apple claims is faster than most portable PCs in both CPU and graphics tasks. It's also thin and light, with a thickness of only 6.9mm and a weight of 712g. On top of that, a single charge will keep the iPad Pro juiced for around 10 hours.

While Aussie pricing has yet to be announced, don't expect it to be cheap — the 32GB model goes for US$799 ($1,143), the 128GB model will be US$949 ($1,357) and the 128GB LTE model will cost US$1,079 ($1,543).

Though Steve Jobs loathed the idea of styluses, Apple has created one specifically for the iPad Pro. The Apple Pencil features advanced sensors to give budding artists and creatives a much higher level of precision, and has been priced at US$99 ($141). A Smart Keyboard was also unveiled, featuring a smart connector port to eliminate the need for Bluetooth, which is priced at US$169 ($241).

Will the iPad Pro will have mass appeal? Hard to say — it's quite pricey for a device that lacks a full-featured desktop OS. The absence of mouse or trackpad support could also be a turn off for many users in the business sector.

We'll have a better idea leading up to the iPad Pro's release this November. It'll come in silver, space grey and gold. Keep an eye out for a full hands-on rundown in the near future.
Stephen Lambrechts

United States and China working on cyber peace treaty
They promise not to attack each other (during peacetime).

When it comes to cyber security, things have been heated between the United States and China recently, with the US at one point considering the placing of sanctions against China over alleged cyber attacks. However, it appears the two nations are making nice once again, with the New York Times reporting that the global powerhouses are negotiating a cyber peace treaty. The goal is for each country to commit to not being the first to attack the other during peacetime. While China has recently been accused of cyber attacks against the US that saw millions of government employees have their personal data stolen, it's expected that the treaty will focus on thwarting attacks on critical infrastructure such as banking systems, power stations and hospitals. The treaty is said to be based on a code of conduct set by the United Nations, in an effort to prevent activity "that intentionally damages critical infrastructure or otherwise impairs the use and operation of critical infrastructure to provide services to the public."
Stephen Lambrechts

BitTorrent traffic share hits new low

Are good, affordable legal options like Netflix finally helping turn users legit?

According to a recent report from the network management company Sandvine, it appears that the total amount of internet bandwidth spent on BitTorrent traffic in Europe has fallen significantly in the last year, dropping below 10% for the first time since the file sharing boom commenced. The report states that 8.44% of Europe's total internet traffic can be attributed to peak hour torrenting, which is a far cry from the 17.99% that was reported only two years ago. And it's not just Europe — the Asia Pacific region is also experiencing the same downward trend. So what's behind the huge decline in torrent traffic? Perhaps easy access to content through legal channels has had a hand in turning pirates into legitimate media consumers — a Sandvine report from May this year stated that 36.5% of all downstream peak hour internet bandwidth in North America could be attributed to the streaming giant, Netflix. During the same period, 15.6% of all peak hour traffic was accounted to YouTube.
Stephen Lambrechts

App Store suffers major malware infection
...but experts say no real damage was done.

Apple's App Store experienced its first major attack recently, as a tainted version of the Cupertino company's developer tools led to over 4,000 malware-infected apps slipping past its rigorous app review and submission process. The infected apps, which originate mostly from China, were created using XcodeGhost, a counterfeit version of Apple's app creation software. Due to China's strict internet filtering policies, legitimate app developers in the country are routinely forced to find alternative domestic sources for their developer tools. While these developers thought they were using a legitimate version of Xcode, they instead ended up with something far more malicious. Apple has already removed the infected apps, including the Chinese build of *Angry Birds 2*, stating that they "are working with the developers to make sure they're using the proper version of Xcode to rebuild their apps." The malicious code works by compromising the app user's privacy, leaking their personal information to hackers. Thankfully, Ryan Olson, Palo Alto Networks' director of threat intelligence, has stated that no real damage was done.
Stephen Lambrechts

A new Facebook button is on the way...
...but it won't exactly be a 'dislike' button.

Though Facebook users have wanted a 'dislike' button for as long as the social network has been around, Mark Zuckerberg has other plans — the CEO has revealed that Facebook is implementing a way to show empathy in posts where a 'like' would seem inappropriate. Though it's unclear what that button will be, Zuckerberg has stated that it won't be a 'dislike' button.
Stephen Lambrechts

And Apple's first Android app is... 'Move to iOS'
Cheekily tells you to 'recycle' your Android device.

Apple has released its first Android app — Move to iOS, an app which allows users to seamlessly and easily move their important data over to the iOS ecosystem, including contacts, messages, bookmarks, mail accounts, calendars and even photos and videos. Move to iOS works by securely transferring your stuff over a Wi-Fi network created by your new iPhone or iPad.
Stephen Lambrechts

Hitachi puts an AI in charge of productivity
Looks set to terminate workflow problems.

Ever had the sneaking suspicion that your boss is a robot? If you work at Hitachi, that could very well be the case — the Japanese multinational conglomerate has been experimenting with artificial intelligence software designed to increase productivity amongst workers by handing out tasks and issuing workflows in real time. The company has already seen an 8% increase in productivity since implementation.
Stephen Lambrechts

US$1M

THE AMOUNT OF APPLE GOODS INVOLVED IN A FUMBLED LAPTOP HEIST.
In September, four US men appeared before a court in White Plains, New York for involvement in a botched plan to steal 1,200 MacBook Airs that were en-route to two public schools. The accused ringleader worked as a driver for the shipping company that was responsible for transporting the laptops, and reported to police that his truck was stolen on the day the devices went missing. But the driver's phone location data points to theft and since the truck showed no evidence of break and enter, he's found himself the prime suspect.

5 years

THE TIMELINE FOR THE CONSUMER RELEASE OF MICROSOFT'S HOLOLENS HEADSET.
Microsoft showed off a demo of its exciting HoloLens augmented reality headset at a developers conference in April, and promised at the time to have headsets for developers in 2016. But in a more recent interview in September, Microsoft CEO Satya Nadella let drop that for the tech giant, the HoloLens "is really a five year journey." And if you were hoping to play *Minecraft* on your dining room table next Christmas, you'll likely be disappointed to know that Nadella also mentioned the headsets would be designed for business applications first.

30K

HP PLANS TO SLASH EVEN MORE OF ITS WORKFORCE.
Earlier in the year, Hewlett-Packard announced that it was set to complete its long-term layoffs of 55,000 employees that begun in 2012 (approximately a sixth of its workforce) by October, which form part of its plans to spin off its faster-growing enterprise segment. Though it had only been a few months since this announcement, HP said that it would be adding another 30,000 jobs to the global redundancy tally, primarily in the corporate hardware and services operations areas.

600 Mbps

HOW FAST YOUR NEXT SMARTPHONE MIGHT BE ABLE TO DOWNLOAD OVER 4G.
It's a bit silly isn't it? Considering that the majority of Australia's broadband infrastructure sits somewhere between 10 and 30Mbps, the announcement that Qualcomm is building smartphone modems capable of speeds 200 times faster than that, all we can really do is laugh. The new Snapdragon 820 is even theoretically capable of speeds six times faster than our current NBN plans — or to put it another way, it could safely stream 12 movies in 4K simultaneously, according to current Netflix requirements.

10M

THE NUMBER OF IPHONE 6Ss APPLE HOPES TO SELL OVER ITS OPENING WEEKEND.
Apple opened the virtual doors to pre-order the new iPhone 6S and 6S Plus models on the 12th of September — two weeks before the devices officially go on sale — and within the first 24 hours the devices had already racked up over 4 million pre-orders. According to Apple spokesperson Trudy Miller, the 'strong sales' put Apple on pace to surpass the company's biggest opening weekend with over 10 million units sold.

tech**notes**

» GEAR WE WANT

UO SMART BEAM LASER
US$420 | UOBEAM.COM

There are times when your smartphone's screen just won't cut it, say for example, when you're watching a movie. And though it'd be great if we could all carry a projector around with us, even the smallest 'pico' models tend to be both bulky and kinda expensive. Korean tech manufacturer United Object may have a silver bullet for this, in the form of the UO Smart Beam Laser. This little 6cm cube is packed with a 4200mAh battery, a 60-lumen liquid-crystal on silicon laser projector, a 1-watt internal speaker and Wi-Fi streaming connectivity. This contraption can reportedly project a movie between 20- and 100-inches at 720p resolution from your smartphone and, because it's laser-based, it doesn't require manual focusing. **JB**

BATBAND
US$149 | STUDIOBANANATHINGS.COM

There are a few categories when it comes to headphones, but generally they will fall into either in-ear, on-ear or around-ear (aka over-ear) models. One ambitious Kickstarter wants to add to the emerging category that is 'non-ear' headphones — or more technically, inner-ear headphones. The Batband headphones wrap around the back of your head but never actually touch your ears, instead using vibrations directed at your skull and the bones in your inner-ear to transmit sound, freeing up your eardrums to hear the world around you. Bone-conduction technology like this has been on the market for a while, although in our testing we've found the audio to be a bit lacklustre. We'll have to wait 'til April 2016 to see if these perform any better. **JB**

3DR SOLO
$1,800 | 3DROBOTICS.COM

3DRobotics has dubbed its latest quadcopter a 'smart-drone' and as far as bylines go, it's bang on. Drones that can carry a camera and gymball are at a size where you need a dedicated controller and quite a bit of practice just to operate them without crashing, let alone getting good footage. But 3DR has put 1GHz ARM A9 processors in both this Solo drone and its controller, and has also written some impressive code to make moving shots like panning, tracking and orbiting a fully automatic process. These units are pricey — and you'll need to BYO GoPro as well — but they're also surprisingly user-friendly and it won't take long to take your aerial cinematography sky high. **JB**

EXPLORIDE
US$499 | EXPLORIDE.COM

Smart cars are the talk of the tech world amid rumours of Apple's involvement. But rather than shell out on an expensive vehicle kitted out with smart features, you could simply buy an Exploride, which promises high tech for a low price. Due to hit the road in January 2016 in the US, this devices is a head-up display that lets you have smart features in a not-so-smart car. You can view maps, access music, take iPhone calls and more using gestures or voice commands, making it much safer than blindly fumbling for the car radio dial.

PARROT HYDROFOIL MINIDRONE
US$180 | PARROT.COM

The latest drone from Parrot combines a miniature drone with a hydrofoil — when the two are attached, the drone rises to form a vertical, electronic sail that powers the hydrofoil. It can then be unclipped and flown separately like a regular drone. It's Parrot's first foray into the world of hydrofoils and it looks good to us. Combining aquatic and aerial electronics means you get the best of both worlds, all at a much more affordable price than most drones. We're looking forward to seeing where Parrot takes this line next.
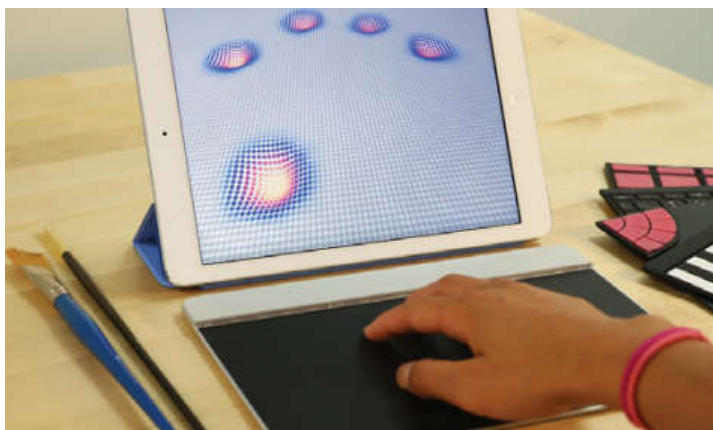
SENSEL MORPH
US$249 | SENSEL.COM

When we look back on the 21st Century, the touch screen will be one of the — if not the — inventions that most shaped how we interact with technology and the world around us. The Sensel Morph has the potential to take that revolutionary tech a step further by adding fine pressure sensitivity. The slab of polymer and metal will detect just how hard you're pressing your fingers on its surface, but is also sensitive enough to detect a paintbrush lightly swishing over the top. Couple this with customised overlays and the flat pad becomes anything you want. Demos at the moment show people using it as a keyboard, a DJ deck, a remote for a robot, but it's just begging for the next big idea. **PT** ∎

technotes

The difficulty of removing the S1 casts serious doubt on the idea of swapping out the internals.

Apple has annoyingly used incredibly tiny tri-wing screws, when Torx or Phillips could've been used.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit **www.ifixit.com**.

Apple Watch Sport
It's hard work cracking this one open.

BACKGROUND

You may have heard of the Apple Watch? Apparently, there's been some hype. You may also have heard about the IHS Technology report, which claimed hardware costs only account for 24%, or US$83, of the Watch's US$349 retail price. So, is Cupertino's latest something to get excited about?

MAJOR TECH SPECS

- Flexible, touchscreen AMOLED Retina display
- Custom-designed Apple S1 SiP (System in Package)
- 8GB onboard storage, Watch OS
- NFC, Wi-Fi 802.11b/g/n, Bluetooth 4.0
- Accelerometer, gyroscope, heart rate monitor, mic, speaker

KEY FINDINGS

- If you're looking forward to swapping out bands, there's not much to it. A button on the back case releases a spring-loaded metal peg in the band, allowing it to slide right out. There are no external screws, however, so we reattach the band for leverage and use a knife to get inside the belly.
- Disconnecting the display isn't easy, as the display cables are trapped under a springy bracket. A quick flick dispatches the light adhesive securing the 3.8V, 0.78W Lithium-ion battery. Apple claims the 205mAh battery should provide up to 18 hours of use. It seems small in comparison to the 300mAh batteries found in the Moto 360 and Samsung Gear Live.
- We encounter the tiniest tri-wing screws we've ever seen, before getting to the speaker, which comes equipped with an O-ring for water resistance. Behind a very small panel we find a set of contacts that align perfectly with the location of the hidden diagnostic port. We remove the Digital Crown bracket, the final obstacle keeping us from the S1 SiP.
- The back of the S1 isn't pretty — with ribbon cables running to every peripheral and gobs of adhesive gripping it in place. Pulling this mess out is destructive. It's a solid block of plasticky resin, hiding treasures deep within, such as the STMicroelectronics C451 gyroscope and accelerometer.
- Back to the display panel, we find a lonesome chip: Analog Devices AD7166 ARM Cortex M3-based Touchscreen Controller. At the bottom is the pulse-pounding sensor action. And lenses. Apple's heart rate monitor is actually a plethysmograph — it looks and acts like a pulse oximeter.
- Repairability Score: 5 out of 10 (10 is easiest to repair). The band is easily removed and swapped. Removing the screen is difficult, but not impossible. Once inside, the battery is quite easy to remove — only mild adhesive holds it in place. While not proprietary, incredibly tiny tri-wing screws are a repair hinderance. Removing any other component is essentially impossible — all peripheral cables are soldered onto the back of the S1. The fully encased S1 system makes board-level repairs impossible.

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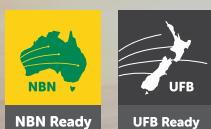
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tech**notes**

> "I have an older HP laptop with Linux Mint 17.2 KDE for my office duty, which is awesome! It replaced SUSE 13.2 KDE, which is good but slow to change."

SUPPORT THE COMMUNITY

I read your editorial (*APC* issue 420, page 3) where you reflected on the relevance of Windows 10. We have decided to move on from Microsoft, and I will quickly explain why. Microsoft costs us time and money, to the extent that we can hardly get on with our actual work some days because we have to fix up and administer our PCs. Ubuntu is quicker, cheaper, stable, and totally flexible.

I could go into greater detail about lost time; bad updates — it's awesomely frustrating to power up in the morning and your operating system has been "improved" and nothing bloody works anymore; the painful time-wasting of new installations and restoring from backups; woeful phone support systems, the list continues.

Our Ubuntu systems on the other hand, just work. You can turn off updates if you want, and they still work — no virus, ever. Auto updates are quick and painless. Everything is free, it's just incredible.

Yes, the Libre Office packages are a little troublesome now and then. And you need to be a bit of a geek to do some things, but whatever you learn is for keeps. Your knowledge won't become redundant after then next update — I can finally keep adding to our knowledge, and run our businesses efficiently.

Finally, I donate funds to all of the open-source people/organisations that help us run our business. These organisations make it possible for us to operate for free, and I'm going to help them continue on. Even with the donations, open-source is so much cheaper than Microsoft, and I enjoy contributing to the community.
Karl Grimm

ANOTHER WINDOWLESS HOME

Yes, my wife and I have moved on from Windows. She has a Mac laptop for office work, plus an iPad mini and iPhone for personal email and Facebook — they suit her social lifestyle better!

I have an older HP laptop with Linux Mint 17.2 KDE for my office duty, which is awesome! It replaced SUSE 13.2 KDE, which is good but slow to change. Ubuntu is just too individual for my taste! Gnome-based OSs also seem to lack polish. The Mint community and support is very active too. I also have an iPad and Android smartphone for email, Twitter and Facebook. We are both Wi-Fi users.

The old Windows 7 desktop is gathering dust!
Steve O'Donnell

ABORT!

I decided to take the plunge to Windows 10 on a slightly older (Core i5) Gigabyte laptop. Most things seemed to go well, but try as I might, I followed every lead I could find on the internet and I just couldn't turn on my Atheros Wi-Fi module. So I'm bailing out and returning to the security of Windows 7 on that machine.
Peter Mayer

THINK OF THE LITTLE GUYS

I recently read the September issue of *APC*, and since I was planning to upgrade my existing PC, I was eager to read your headline article regarding storage.

To my dismay you reviewed PCIe SSD's plus other storage such as cloud and NAS but didn't review any 2.5-inch SSDs. I can understand not doing a review of mechanical drives as the price of SSDs have relegated them to storage of data rather than operating systems and programs, but to leave them out of this article seems surprising.

I hope you might consider a review of SSDs of sizes around 240GB which would be a decent size for OS and programs in an issue in the near future.
Max Schafer

Ed replies: **We've got a 'regular SSDs' feature in the pipe Max; we couldn't fit it and all the other storage gear we wanted to look at into the September issue! Stay tuned.**

BATCH TO THE FUTURE

I think your adviser Luis Villazon was a bit harsh and perhaps ignorant of the use of batch files (*APC* issue 420, page 74). While the uses he was replying to really were a waste of time and resources, there is still a place for batch files. They're far from a 90s left over and are constantly being updated with new features.

They are, for example, much quicker and more efficient at backing up files than any GUI program I have come across — a few lines of code can achieve so much.
Bruce Lloyd ■

Nothing is forever — especially when it's digital

Shaun Prescott believes software publishers need to do more in order to ensure access — and posterity — is preserved for digital titles.

Before the internet, you'd buy software in a bricks and mortar store. If that software sold out, you'd buy it second-hand. If it became rare, you paid a lot of money. Those days are long gone, and one of the enduring anxieties of the internet age is the ephemeral nature of digital goods. Theoretically, digital distribution ensures a limitless supply, but major software publishers don't see it that way at all.

Case in point: in early September, Electronic Arts removed a long list of iOS and Android games, including genre-defining Australian-developed titles like *Real Racing* and *Flight Control*. While those who have purchased the titles can still play them — provided they're already installed — those who haven't will no longer have access to these titles. If you do have them installed, there's no guarantee future Android and iOS system updates will support them. In effect, the games have been deleted from history.

In this particular instance, it's easy to dismiss the news as unremarkable: besides, few people cherish smartphone games. But aside from questions of posterity and history, it sets an alarming precedent: when we pay to "buy" a game, are we really buying it, or are we effectively just renting access? In an era of rapidly-obsolescent platforms, it feels like nothing is forever. The same has always held true to an extent — try getting the original *Doom* to run on your PC without an emulator — but the important distinction here is accessing the material. You simply can't play *Real Racing* anymore, and there's no guarantee even if you 'own' it. Updating software for each new smartphone OS release is a costly business, and from a fiscal point-of-view EA's move makes a cruel kind of sense. But during a period when publishers, developers and gamers alike talk about "meaningful experiences" and even "art" in the same breath as games, the industry will need to work harder to demonstrate that they really care about the medium.

In too deep
Sony talks the limits of waterproofing.

While most consumers know that 'waterproof' doesn't mean you can post on Instagram while deep sea diving, Sony's messaging for the Xperia has been very strong, to the extent that the company has re-jigged its guidance notes to clarify what 'waterproof' actually means. "The recent changes to guidance we provide are designed to more clearly illustrate the best ways to protect devices in day-to-day usage," the company wrote. "We communicate necessary precautions, and the specific parameters of ingress protection ratings, to help customers to protect their smartphones and tablets in line with the applicable warranty we provide." What does that mean? Well, unlike some of Sony's marketing material depicting users taking photos underwater, you actually probably shouldn't do that. "You should not put the device completely underwater or expose it to seawater, salt water, chlorinated water or liquids such as drinks. Abuse and improper use of device will invalidate warranty." On the other hand, exposure to liquids is OK. Whether that means you can take your phone in the shower is unclear. Sony should know better than to use flagrantly misleading marketing material: early in the company's marketing campaign for the PlayStation Vita handheld, advertisements depicted users streaming games from their home console (PS3) while on the move. While that functionality does exist it's severely limited. SCEA commenced the distribution of class action settlement offers back in April, after accusations of false advertising were levelled against them in 2012. It goes to show that Sony's marketing department should probably pay closer attention to the realities of the company's products. ■

✓✓✓ apc RECOMMENDS

✓✓✓ apc RECOMMENDS

TABLET

8-INCH WI-FI, $499; 8-INCH LTE, $649; 9.7-INCH WI-FI, $599; 9.7-INCH LTE, $749 | WWW.SAMSUNG.COM/AU

Samsung Galaxy Tab S2

Samsung's latest tablet can finally holds its own against the iPad.

With the original Galaxy Tab S, Samsung finally provided Apple's iPad with some serious competition in the tablet space. Now, the Korean company is back with what's perhaps its most overt attempt to deliver its own iPad-like experience — and for the most part, the Galaxy Tab S2 succeeds.

Direct comparisons to Apple's tablets are easy to make, with the S2 adopting the iPad's signature 4:3 aspect ratio and eschewing the 10.5-inch and 8.4-inch displays of the original Tab S in favour of 9.7-inch and 8-inch versions. The larger model has also been rotated 90 degrees, with its home button (which has a slicker touch-based fingerprint scanner) moved to make the tablet more comfortable when held vertically. While this might annoy those who use their tablets primarily for viewing video content, it makes web browsing and reading much more natural.

While the iPad was very obviously an inspirational factor in the S2's form, the rest of the tablet is pure Samsung. The S2 has a metal frame with a thin chrome edging and a rear that's made of smooth plastic. Sure, it's not particularly grippy or quite as premium as the iPad's aluminium chassis, but it's very comfortable to hold in the hand. It's also lighter and thinner than the iPad Air 2, weighing in at just 392g for the 9.7-inch and 272g for the 8-inch, with a thickness of only 5.6mm for both models (for comparison's sake, the iPad Air 2 weighs 444g and is 6.1mm thick). Samsung's signature capacitive buttons make a return, and the device's power button can still be found on its side. It's also got a microSD Card slot, which can add up to 128GB of storage, and just below that (on the LTE models of the Tab S2) is where you'll find a Nano-SIM slot.

The S2's display matches the iPad Air 2's resolution exactly (1,536 x 2,048 pixels), even sharing the same 264ppi pixel density (320ppi on the 8-inch version) as Apple's IPS display. That said, we might give the edge to the S2, as its Super AMOLED display is breathtakingly vibrant, with a brightness and depth of colour and contrast that make the iPad Air 2 seem muted by comparison.

Though Samsung's latest runs a slightly outdated version of the Android OS (5.0.2 Lollipop), it does boast some software tweaks of its own, including Quick Connect functionality — this allows you to sync with a nearby (compatible) Samsung smart TV to throw video content at it.

In terms of performance, the S2 performs admirably, if not spectacularly. Though it's much quicker than the original Tab S, it uses an older Exynos 5433 octa-core processor developed for last year's Galaxy Note 4. Unsurprisingly, it performed similarly to that handset in our graphical benchmark tests, but was left in the newer Galaxy S6's Exynos 7420-sporting dust.

Its battery capacity is also a downgrade from the Tab S1 — the 9.7-inch Tab S2 has a 5,870mAh battery (compared to the 7,900mAh battery in the 10.5-inch Tab S), while the 8-inch model sports a 4,000mAh battery (4,900 mAh in the original 8.4-inch version). Still, in PCMark 8 Android's tough battery life test, this 9.7-inch model lasted a respectable 7:12hr.

Though it's perhaps a little disappointing that the Galaxy Tab S2 doesn't pack Samsung's latest Exynos CPU, it's the most attractive tablet the company has ever made, and also the most pleasurable to use. It feels as though Samsung's finally nailed its iPad competitor this time around.

■ **Stephen Lambrechts**

Verdict

Features	★★★★½
Performance	★★★½☆
Value	★★★★☆

It's not the most powerful tablet, but the S2 is beautifully designed, with a gorgeous and vibrant display.

★★★★☆

General system performance

PCMARK 8 - HOME	OVERALL SCORE
ACER ASPIRE R11	1,722

0 1000 2000 3000 4000 5000

X264 HD BENCHMARK 5.01	AVG FPS
PASS 1	12.34
PASS 2	2.1

0 4 8 12 16 20

Gaming performance

3DMARK	CLOUD GATE - OVERALL SCORE
ACER ASPIRE R11	2,112

0 1000 2000 3000 4000 5000

Battery life

PCMARK 8 HOME	HOURS:MINS
ACER ASPIRE R11	7:20hr

0 2 4 6 8 10

PEACEKEEPER	WEB SURFING - HOURS:MINS
ACER ASPIRE R11	DNF

0 2 4 6 8 10

HYBRID LAPTOP

$699 | WWW.ACER.COM.AU

Acer Aspire R11 (Windows 10 Edition)

A laptop/tablet hybrid that offers good versatility on a reasonable budget.
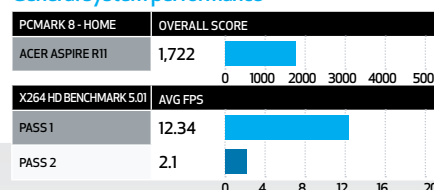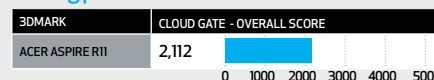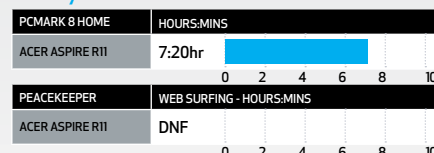
Nestling squarely into the hybrid laptop category, the new Aspire R11 is the first device we've tested that's shipped with Windows 10 — and it couldn't be a better fit. The R11 is part tablet, part laptop and Windows' new OS allows the device to automatically flick between the optimal mode for each.

Wrapped in a fairly durable-feeling blue plastic with a coarse pattern, this fixed hinged laptop allows the screen to swivel a full 360 degrees and rest on the underside of the keyboard. The screen doesn't detach, but the lightweight plastic casing makes the 1.6kg unit an acceptable weight for tablet use on the lap. In fact, the overall hardware design is quite good: the trackpad is centered just below the keyboard and is a good size, the keys are a black-textured plastic that are spaced nicely (it's better for typing than some of the budget laptop keyboards we've tested) and the 11.6-inch, 1,366 x 768-pixel LCD touch screen is quite passable for the price.

As with all budget laptops, there are a few caveats to this model however. While that plastic shell might look tough, it actually marks quite easily and the Aspire R11 is so lightweight that, on a wooden desk, when you try and click-and-drag you're equally as likely to slide the whole computer across the table instead. We found the security software suite that was bundled-in had a habit of absorbing precious processing power at inconvenient times — like when running on battery — and could make tasks like web browsing less responsive.

Despite having twice the RAM of Microsoft's similarly-priced Surface 3, the R11's overall performance was merely on par with the latter in many of our benchmarks. The R11 outpaced the Surface 3 slightly in terms of typical work and home computing tasks, but lagged by about the same margin when it came to graphics processing.

This makes sense on Acer's behalf and, in theory aligns with the task set required by the Aspire R11, but with a poorer-quality screen and inferior graphics it feels more like an entry-level device. Then again if you plan to add the $180 keyboard to the Surface 3, then the R11 and its built-in Ethernet, HDMI, USB 3.0 and USB 2.0 ports starts to make more sense as an affordable device, erring on the laptop side of the hybrid divide.

Though the R11 only has a 1,366 x 768-pixel screen (for comparison, the Surface 3's 1080p) its colour reproduction was surprisingly good and thanks to Zero Air Gap technology between the touchscreen and the inner display panel, the amount of reflected light is notably reduced.

The R11 also has solid battery life, pushing the 3,220mAh li-polymer battery to last over 7 hours under normal work conditions. There's even a decent set of speakers that will flip based on screen orientation. In short, there's definitely some intriguing aspects here for a budget laptop-tablet hybrid.

■ Joel Burgess

Verdict

Features	★★★★☆
Performance	★★★★☆
Value	★★★★☆

A decent budget laptop that throws in a ton of tablet and alternative display features.

★★★☆☆

BUDGET LAPTOP

$359 | **WWW.KOGAN.COM.AU**

LABS | BENCHMARK RESULTS

General system performance

PCMARK 8 - HOME	OVERALL SCORE					
KOGAN ATLAS X14FHD	1,331					
	0	1000	2000	3000	4000	5000

X264 HD BENCHMARK 5.01	AVG FPS				
PASS 1	13.92				
PASS 2	3.93				
	0	4	8	12	16	20

Gaming performance

3DMARK	CLOUD GATE - OVERALL SCORE					
KOGAN ATLAS X14FHD	1,553					
	0	1000	2000	3000	4000	5000

Battery life

PCMARK 8 HOME	HOURS:MINS				
KOGAN ATLAS X14FHD	3:00				
	0	2	4	6	8	10

PEACEKEEPER	WEB SURFING - HOURS:MINS				
KOGAN ATLAS X14FHD	3:08				
	0	2	4	6	8	10

Kogan Atlas X14FHD

Can this budget-laptop sequel match up to Kogan's original Atlas?

I t's fair to say we really liked Kogan's original 15.6-inch Atlas laptop from late last year — a $329 device that impressed us by covering all the basics a notebook should and even going beyond them in some spots, like its very solid 5-6 hour battery life.

> "This new replacement is a bit smaller at 14-inches, but it bumps the display resolution from 1,366 x 768 up to 1,920 x 1,080 in compensation."

This new replacement is a bit smaller at 14-inches, but it bumps the display resolution from 1,366 x 768 up to 1,920 x 1,080 in compensation. It's largely the same under the hood, however, with an identical 2.16GHz Intel Pentium processor (the quad-core N3540), 500GB Toshiba hard drive and Windows 8.1 for the OS. (And as with all Windows 8.1 devices, you can get a free upgrade to Windows 10 until next July.) There are even some surprising elements, like the inclusion of 802.11ac Wi-Fi and physically it doesn't look too shabby either.

The admittedly plain chassis is all plastic (frankly, you're dreamin' if you expect anything better at this price point) and a tap of the palm rest areas will tell you it's a bit hollow inside, but that 14-inch size makes it a little more portable and at 2.1kg with a compact charger it's not too hard to take with you.

That new 1080p screen is pleasing too — it's reasonably neutral in terms of colours, with a tight pixel-pitch meaning images are quite clean — there are no ugly horizontal lines running across the screen, like we've seen on some other budget laptops.

In use, that cheap-and-cheerful demeanour continues; it covers simple computing needs (web, light office tasks, video playback), but has trouble with more demanding tasks like gaming (*Angry Birds* — yes; *Call of Duty* — no). The keyboard and trackpad are both serviceable but far from exceptional, and the mechanical hard drive means it's not as responsive as a system with an SSD — apps can take a little while to first launch, and system searches on the Start screen are on the slow side.

Performance wise, though, there's only one key spot where this 14-inch model isn't as good as its predecessor — battery life. Here, it's about half the older model's 5-6 hours; at most, you'll get about three-and-a-half hours. That higher-res screen is likely the main culprit and while the battery shortfall is a bit disappointing, it's not quite a deal breaker — really, it only seems poor because the older model was comparatively so good.

The other main caveat is that this new Atlas isn't quite as keenly-priced as its $329 forebear. That's something that the higher-res screen and lower value of the Aussie dollar somewhat help justify. It's worth noting Kogan has two models on offer — opting for the version with 4GB of RAM instead of 2GB will cost you an extra $10, but is something we'd strongly recommend. ■ Dan Gardiner

Verdict

Features	★★★★☆
Performance	★★★☆☆
Value	★★★★☆

A solid — if not quite outstanding — budget laptop offering that does the basics, but not much more.

★★★★☆

apc RECOMMENDS ✓✓✓

GAMING LAPTOP

$3,199 | WWW.AORUS.COM

Aorus X5

Putting a cap on too-hot gaming laptops.

LABS	BENCHMARK RESULTS

General system performance

PCMARK 8 - HOME	OVERALL SCORE
AORUS X5	4,304

0 1000 2000 3000 4000 5000

X264 HD BENCHMARK 5.01	AVG FPS
PASS 1	59.75
PASS 2	14.95

0 4 8 12 16 20

Gaming performance

3DMARK	CLOUD GATE
AORUS X5	23,545

0 5,000 10,000 15,000 20,000 25,000

METRO: LAST LIGHT	1080P, ULTRA - AVG FPS
AORUS X5	60.67

0 20 40 60 80 100

BIOSHOCK INFINITE	1080P, ULTRA - AVG FPS
AORUS X5	95

0 20 40 60 80 100

Battery life

PCMARK 8 HOME	HOURS:MINS
AORUS X5	1:49

0 2 4 6 8 10

PEACEKEEPER	WEB SURFING - HOURS:MINS
AORUS X5	2:08

0 2 4 6 8 10

Gaming-laptop maker Aorus has been building a reputation for its ambitious slimline machine for a few years now and this 15.6-inch model, just 23mm thick, is its latest reworking of that formula. Like its siblings, the X5 comes at a premium price, but does try a bit harder than other gaming laptops by incorporating features that gamers can actually use. Specifically a G-Sync display (making for some buttery-smooth gaming visuals), two GeForce GTX 965M graphics chips in SLI and a row of macro keys on the left side of the keyboard, letting you record and replay a series of keystrokes in game. Plus, there's a copy of X-Split GameCaster included for budding game-streamers.

The other core hardware is pretty good too: a very quick quad-core Core i7-5700HQ processor, 16GB of RAM and storage that's adequately covered by a couple of drives: a 512GB unit for the OS that's actually a RAID 0 setup made of two M.2 SATA 6Gbps SSDs — they're lower-cost Liteon 256GB units, but combined they do manage quite high speeds, nearing 1,000GB/s. (We'd have preferred a single PCIe M.2 drive — something like Samsung's SM951 — but that would have pushed the price up.) A second 1TB mechanical drive gives you a good amount of general space.

That 15.6-inch screen has a higher '3K' resolution — meaning 2,880 x 1,620 pixels — and it's an IPS job, with excellent clarity, contrast and colour-reproduction; there's nothing to complain about here. G-Sync works well in eliminating any tearing while gaming and the two GTX 965M's can drive most games at 100fps speeds on medium details. (For high or ultra settings, you'll need to drop the resolution down to 1080p.)

The one main problem with thin gaming laptops is that high-performance CPUs and GPUs generate a lot of heat, and to get that out they employ high-speed, extremely loud fans.

The X5 does at least offer you some options here though, with three manual fan speed modes: Quiet, Normal and Gaming. On Normal and Gaming modes, the fans will spin up quite aggressively — even for non-gaming tasks. In Gaming they're especially hyperactive: we found even just downloading Windows updates was enough to kick the fans into medium gear and be quite audible.

Switching to Quiet mode is in some aspects the best option all round. Using it does two things. The first, obviously, is to slow the fans so that they're only spinning at lower, quieter speeds. That doesn't mean it's silent, but it's nearly so.

And second, to make sure those fans don't ever actually need to run fast, the X5 caps game framerates at 30fps. That has a significant impact on GPU and CPU temps (dropping them from 75/95°C to 65/71°C respectively), but means games are still comfortably playable. Not quite the 'best' of both worlds, but a good compromise — and one that, if used, should increase the lifespan of the device.

Battery life is also a compromise: you'll get around 2 hours at most, something that's typical of machines with this kind of high-end hardware. Physically, the X5 has a footprint that's a bit bigger than other 15-inchers — likely necessary to squeeze all that hardware in — with a wide bezel around the display.

It's a shame that you can't use all that power without this one sounding like a hairdryer, but this is perhaps the most 'healthy' slimline gaming laptop we've yet tested. ■ **Dan Gardiner**
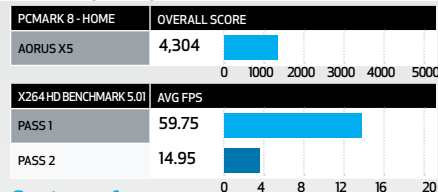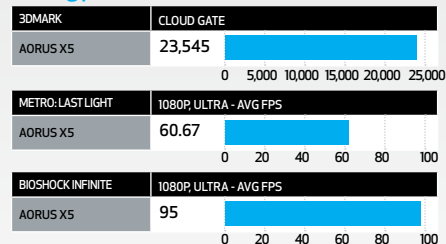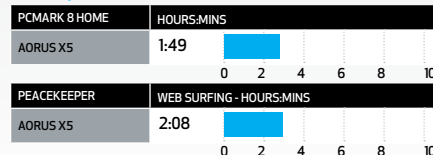
Verdict

Features	★★★★☆
Performance	★★★★☆
Value	★★★★☆

A slim gaming laptop with some sensible design choices that make it better than most others.

★★★★☆

Game scores are minimum/average fps.

Performance comparison

CINEBENCH R15 (INDEX)	OVERALL SCORE
ALIENWARE 15	639
ALIENWARE 15 WITH GRAPHICS AMPLIFIER	654
MSI GS30	612
MSI GS30 WITH GAMING DOCK	636

0 200 400 600 800 1000

BIOSHOCK INFINITE	FPS
ALIENWARE 15	70
ALIENWARE 15 WITH GRAPHICS AMPLIFIER	94
MSI GS30	9
MSI GS30 WITH GAMING DOCK	120

0 40 80 120 160 200

GRID 2	FPS
ALIENWARE 15	68
ALIENWARE 15 WITH GRAPHICS AMPLIFIER	66
MSI GS30	8
MSI GS30 WITH GAMING DOCK	165

0 40 80 120 160 200

METRO: LAST LIGHT	FPS
ALIENWARE 15	32
ALIENWARE 15 WITH GRAPHICS AMPLIFIER	48
MSI GS30	6
MSI GS30 WITH GAMING DOCK	53

0 40 80 120 160 200

GAMING LAPTOP

$2,498 | WWW.DELL.COM.AU

Alienware 15 with Graphics Amplifier

Sure, it's a nice solution. But what was the problem?

Gaming and laptops have never been best mates. The problem is that the confines of a laptop chassis aren't well-suited to a hot, angry graphics chip. They consume so much power. They produce hideous amounts of heat.

So, the traditional choice has been between gaming laptops that were good at portability but not actually that great for gaming, and barn-sized lappies that had decent gaming chops but were difficult to carry around all day.

But what if you could take the gaming grunt out of the laptop's chassis, to allow the laptop to be properly portable but still have gaming goodness? Now you can with the Alienware 15. Actually, this isn't the first time we've seen a gaming laptop like this. MSI's GS30 does the same trick.

Both depend upon a proprietary connection to the external box using PCI Express signalling. But there are differences. For starters, the Alienware 15 sports surprisingly capable graphics in its laptop chassis. There's a mobile Nvidia GeForce GTX 970M GPU. That's important because it means you retain reasonable gaming grunt when you leave the break-out graphics box behind.

The 'Graphics Amplifier' box sports an AMD Radeon R9 290X, which was until recently the fastest desktop GPU offered by AMD. It also brings us to our first worry. This laptop is running both Nvidia and AMD graphics with drivers for both installed in parallel. We didn't have problems during testing. But it makes us uncomfortable about long-term stability.

We're happy to report that with the break-out box hooked up, the video output works fine on both external displays and the 15's own 15-inch panel. The only obvious downside is that the external box with its own PSU is damn noisy.

As for actual gaming performance, well, it's much as you'd expect, whether you're using it like a laptop with the internal GPU or as a desktop with the graphics box, both scenarios are backed by an Intel quad-core Haswell processor. Which is to say, it genuinely works.

And what of the Alienware 15 as a laptop in its own right? Well, it's a nicely engineered lump with a particularly solid and pleasing keyboard. Depending on usage, you're looking at a good three hours or so of battery life. If there are negatives, they involve the 15-inch 1080p LCD panel, which is merely adequate, and the stingy 128GB SSD. Yes, there's a 1TB magnetic drive, but we'd want more solid-state storage.

If at this point you're sensing positive vibes about the Alienware 15, you'd be both right and wrong. On the one hand, it definitely works. However, what completely blows it out of the water is the price. It's so expensive that it simply makes no sense. You'd be far better off with a proper desktop.

That's especially true these days with everything being up in the cloud, in software terms. Simply run Steam and a synced web browser on both boxes, and you've reduced the advantages of having a single box to do it all pretty much to nil. ■ **Jeremy Laird**
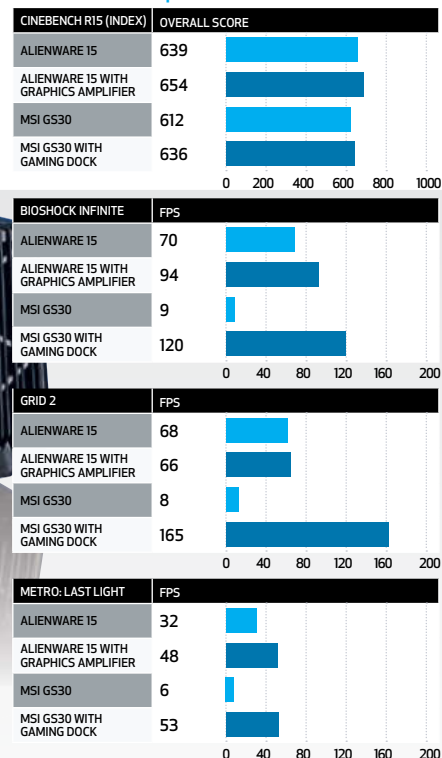
Verdict

Features	★★★☆☆
Performance	★★★★☆
Value	★★★★☆

It's a complex setup but it really works; allows for future graphics upgrades; has decent portable performance.

★★★☆☆

ADSL ROUTER

$549 | WWW.NETGEAR.COM.AU

Netgear Nighthawk X4S D7800

Seriously-impressive Wi-Fi performance at a slightly eye-watering price.

Given that Netgear only just released its first 1,300Mbps 802.11ac ADSL router a few months back, this new 1,733Mbps 'Wave 2' model came as something of a surprise. It's not the first 'Wave 2' 802.11ac device to market (that was arguably ASUS's RT-AC87U router, which hit shelves earlier this year) but it is the first to have integrated ADSL... and that also perhaps helps explain its $549 price tag.

Wave 2 is the next phase of 802.11ac Wi-Fi tech, and one which could ultimately see routers reaching 6.93Gbps transfer speeds — four times as fast as the 1.73Gbps in offer here. That'll require entirely new hardware however — this is more just a first step.

And it's really the high-end hardware in the D7800 that you're paying for here — in terms of software configuration options, they're exactly the same as other recent Netgear routers, including the D7000. What this new model adds is an extra 433Mbps of wireless bandwidth, helped along by a dedicated fourth antenna. Mind you, it's otherwise nearly identical to Netter's other Nighthawks in terms of external design — some add-on ports have been shuffled around (there are two USB 3.0s for attaching storage or printers, plus a dedicated eSATA port), but you still get five Gigabit Ethernet ports in back and one for the ADSL/VDSL phone line.

Now, at present 1,733Mbps Wi-Fi is a bit of a pain in the butt to test — apart from the routers themselves, there are few devices that support this standard; it's not built into any smartphones or laptops, and you won't find a single USB dongle or even PCIe card to let you add it. We managed to secure an ASUS wireless bridge which does have 1,733Mbps (the EA-AC87), but we couldn't get it to play ball with the D7800 within our deadline.

The two devices connected fine, but the ASUS refused to let our test PC see any other devices on the local network — meaning we couldn't test transfer speeds. Even with that testing limitation, however, the D7800 offered some seriously impressive performance — particularly at longer distances. In tests of the latter, this one's dedicated 4T4R (four transmit and four receive) antenna setup help it blitz everything other 802.11ac router we've tested.

In our read test (pulling data from the router to a laptop) most of the competition manages speeds of 30-40MB/s. The D7800 blew past that at 52.9MB/s — only a few MB/s slower than our close-range test. Our write test was more in line with others however — 25.1MB/s, or basically average. What's more, those high speeds held up when we switched to 2.4GHz 802.11n — they were only marginally lower than close range, at 9.5/10.8MB/s for reads/writes respectively.

Also splendid was its very high sync speed — again the highest we've got on record at 17.8Mbps, a full megabit above our lower scorers, netting you roughly 100KB/s extra download speed.

The D7800 could be better in some respects, especially considering its whopping $550 asking price. While it ticks all the basics (automatic or manual QoS, OpenVPN support, guest networks, dynamic DNS, external storage and so on) we would have like to have seen a more visual web interface alongside advanced per-user bandwidth controls — like what competing Fritz!Box devices offer. As it is, you can limit the entire network to a monthly data allowance, but not throttle or limit use for individual devices.

■ Dan Gardiner

Verdict

Features	★★★★☆
Performance	★★★★★
Value	★★★☆☆

You may not be able to use 1,733Mbps in many places, but the long-range performance is phenomenal.

★★★★☆

PC CASE

$180, PRO $220 | WWW.COOLERMASTER.COM

Cooler Master
MasterCase 5 & 5 Pro

Cooler Master builds its most modular case ever, with eyes on expanding the concept behind it.

The MasterCase 5 is pitched as being so flexible that you can customise it to suit almost any desired PC setup and add or remove parts to change the look. Cooler Master's even put together an online store that'll let you order additional extras to make that happen. Off the shelf though, there are two versions of MasterCase you can choose from — a stock version and a Pro edition. Forking out an additional $40 for the latter nets you an extra hard drive cage and front 140mm fan, plus a windowed side panel and an enclosed top section with a water-cooling bracket for installing a 240mm radiator. All those Pro extras can be added individually though.

At the MasterCase 5's core is a solid steel frame, finished in a soft matte-black paint. Not every piece of the exterior is metal — the removable front panel and covers over the two top-mounted arches (which double as handles) are plastic, though they closely-match the metal parts in colour. It's a handsome and angular design, if not quite as striking as some of Corsair's edgier Obsidian series. Inside are all the features you'd expect in a high-end PC case — a cavernous interior that's easy to work in, modular drive bays than can be freely moved about, dust filters at the top, bottom and front, thumbscrews throughout, screwless hard drive and SSD mounts, a cable management system (including a neat recessed-channel behind the motherboard tray) and a dual-chamber design that keeps the PSU isolated at the bottom — good for heat management.

All of these features show care and consideration in their implementation and the build-quality is first class. Our favourite feature of the MasterCase 5 might be its 'clip and click' drive installation system — a pair of rails that run down the front of the case so you can rapidly add or remove drive cages using thumbscrews. Our only real gripe was that many of the thumbscrews were so tight that they required a screwdriver to initially release them. If you want to use a front-mounted 240/280mm water cooler, you'll also have to remove all the hard drive cages.

But while the MasterCase 5 is undoubtedly a very-good case, it doesn't really offer much more modularity or options than its best competitors — everyone's been heading in this direction for some time. Take the excellent Fractal Define R5 that we reviewed back in our Christmas 2014 issue (see page 28), which is a fair bit cheaper, going for around $150 on the street. It's arguably even more flexible if you want to install a water cooler — it doesn't require removing drive cages to front-mount a 240mm radiator.

Cooler Master's plan is to extend this modular approach to its entire range — an admirable goal, which looks to be just getting started. ■ **Dan Gardiner**

Verdict

Features	★★★★☆
Performance	★★★★☆
Value	★★★☆☆

Great build-quality and lots of customisability, but there are slightly cheaper and more flexible options.

★★★★☆

SMARTPHONE

$129 | WWW.KOGAN.COM.AU

Kogan Agora 3G Lite

Smartphones really don't come any cheaper than this.

The Agora 3G Lite is a comfortably-sized handset with a 5-inch screen and despite the Kogan branding, it's actually manufactured by BenQ. It runs Android 5.0.2 on a quad-core ARM Cortex-A7 CPU at 1.3GHz, combined with a basic Mali-400 MP GPU, 1GB of RAM, 8GB of storage, and a 3G cellular radio and a second SIM slot for a 2G card. It even has both front- and rear-facing cameras (at 2MP and 5MP respectively) and the plastic back comes off to give access to micro-SIM and microSD card slots (the latter supporting cards up to 32GB). Combined, that's a phone that can more than handle the basics.

While its benchmark results aren't great, for day-to-day tasks you won't really notice — email, web surfing, music- and video-playback, and even a little light 3D gaming are all possible here. The screen is likewise a bit low-res at 480 x 854-pixels, so images on it aren't particularly sharp, but it's certainly functional.

While its polycarbonate (aka plastic) 155g body doesn't really feel like it could take much punishment (Motorola's budget phones are definitely tougher, though they're pricier too), it should manage just fine if you're not too rough with it.

Battery life is one aspect that's a bit of a let-down. While there should be enough here to get modest users through a day, its PCMark 8 result of 5:13hr is a couple of hours behind most others. The battery is removable though, and Kogan offers extras for $19, which is a nice option to have… though not as good as having a longer-lasting battery, of course.
■ **Dan Gardiner**

Verdict

Shorter battery life aside, this is a very solid handset given the very-low price.

★★★★☆

SMARTPHONE

$129 | WWW.BOOST.COM.AU

Sony Xperia E4

Sony proves it can play the budget smartphone game too.

At $129 outright, this Boost Mobile-exclusive (meaning it's locked to Telstra's network in Australia) smartphone is basically the brand-name counterpart to the Kogan (opposite). With near identical specs — screen-size, CPU, GPU, RAM and storage are all spot on, and there's also a microSD card slot — the only major feature difference is that this Xperia is only a single-SIM 3G device and runs an older verison of Android (4.4.4). The 5-inch display is also slightly higher-res at 540 x 960 — enough to make a slight difference in overall sharpness and clarity for small text — but our test device had a slightly green/yellow tint; skintones in particular look a bit jaundiced.

Performance-wise, the E4 delivers much the same experience: it covers all the basics you need, including basic gaming chops with no real slowdown or lag. Load times can be a bit longer and the E4 is only about 10%-20% the speed of current flagships — but at about 1/10th the price. The E4's rougher textured-plastic back makes this handset feel and look a bit less slick than the Kogan, though that plastic is much thicker here, meaning it'll likely be a bit more robust. The back is also removable, giving access to the SIM and microSD slots, but the battery sadly isn't removable. On the upside it is a bit bigger so doesn't suffer from the same shortish battery-life lasting 7:33hr to Kogan's 5:13hr. That makes this Sony a slightly more well-rounded handset and a better choice overall… provided you're happy to use it on the Telstra network. ■ **Dan Gardiner**

Verdict

An excellent Android handset considering the price, but one that only works on Telstra.

★★★★☆

APC RECOMMENDS

GAMING STEERING WHEEL

$490 | GAMING.LOGITECH.COM

Logitech G920 Driving Force

A well-made, streamlined gaming wheel, but do you need to update?

Logitech's G27 wheel is held in high regard by racing enthusiasts. The G920 and its sibling, the G29, are its successors — the former geared towards Xbox One players, the latter for PlayStation. Both are however PC compatible.

The G920's face buttons and D-pad are in logical positions — an improvement over the G27 — and generally, everything's much more streamlined, though the shifter is now an optional $75 extra. You can't fault how it's constructed, with a stitched-leather wheel, 900° of rotation, and feedback that can absolutely kick — much like the G27. So much of what comes up through the wheel comes from the software, of course: in *Forza Motorsport 6*, Prague's cobblestones gently ripple the wheel, while collisions and locked-up front wheels are violent affairs. A hot front-wheel drive Civic suffers torque steer, and feels as distinct from an all-wheel drive GTR as it

does a lumbering Lambo. The G920 does a beautiful job of translating everything that's happening on the track, so it's disappointing that you're taken out of the moment as the clutch pedal is far too close to the brake. Without a gear shifter as standard, you're left with the flappy paddles; these admittedly do a decent job, though the clamps that secure the unit to your table are a little narrow. However, mounting holes are also present on the wheel and pedals for customisation. The clincher here is that the older G27 is still a fine wheel, and if you have one you're not going to trade it in for a G920. Still, if you're looking for a handsome, well-made piece of kit, the G920 is a wheel steal. ■ **Paul Taylor**

Verdict

Hardy construction, an attractive finish and three pedals out of the box, it's a great wheel.

★★★★☆

APC HOT PRODUCT

GAMING MOUSE

$200 | WWW.ROCCAT.ORG

Roccat Nyth

The nythest MMO gaming mouse we've ever tested.

There's no shortage of multi-button gaming mice like Roccat's new Nyth, but the up-and-coming peripherals-maker reckons its new, customisable design can do one-better.

Pitched at MMO and MOBA (multiplayer online battle arena) players, these mice typically cram 12 buttons onto the left side which are pushed with your thumb, the theory being that this gives you quick access to myriad abilities, alongside the capacity to assign keystroke macros to automate complex series of actions. The main problem with this design is that your thumb isn't that dexterous, and with 12 buttons configured in three rows of four, it can be hard to reliably press the one you want, let alone remember what they all do. The Nyth's answer is to let you rework all 12 of its buttons to customise the layout, with a choice between having no button or substituting a pair of them for a single double-width one. It's a very smart

setup that allows you to insert the exact amount of buttons you want, in a configuration that's comfortable for your thumb. In fact, after using it, there's no way we'd ever go back to a standard MMO mouse.

Some shortcomings do remain however. While this isn't a particularly bulky mouse, it's still on the heavy side — if you like something you can flick around your mousepad effortlessly, this isn't it. The fin switch on top is also pretty useless in play, given that it's wedged at the base of your index and middle fingers. And then there's that price. At $200, you'd have to be a pretty devoted MMO or MOBA player to even consider buying one… ■ **Dan Gardiner**

Verdict

The best MMO and MOBA mouse we've found yet, with simply outstanding customisation .

★★★★☆

VENOM

BlackBook
17

Now Slimmer, Lighter & More Powerful

MECHANICAL KEYBOARD

$149 | WWW.CORSAIR.COM

Corsair Strafe Mechanical Keyboard

Clicky quality from sensitive switches.

Corsair is a brand synonymous with solid build quality and premium feature sets, and the Strafe doesn't disappoint. Packing Cherry MX Red keys, it's quiet, but still has the mechanical sound and feel of Cherry's clackers.

The overall build quality of the Strafe is impressive. Although it has a plastic outer shell, the keyboard itself has very little flex. And while it lacks the classy metal chassis of its older K70 Vengeance brother, it's still a good-looking keyboard with a set of outlying LED stripes to complement the gaming feel. It also features an LED controller that means you can have any number of complex LED wave patterns and responses to boot. Other features include media control via the function keys, brightness control and a Windows lock key. The board also comes with a USB passthrough, which is handy. You can even change out the key caps and the more traditional WASD keys. The

only downside is the lack of truly dedicated media keys. However, for the price point, it's understandable why. Other than that, a wrist rest would have been a bonus, too, as it can sit a little high on your desk. Granted, there are alternative mechanical keyboards for this price, but none of them feature the same integrated LED controller or the modern level of gaming aesthetic. That said, you can pick up a K70 Vengeance in red for the same price — despite its slightly dated design, the dedicated media keys and all-aluminum body make it incredibly tempting. But if you like pretty lights and want a solid, dependable and versatile gaming keyboard, the Strafe is worth considering. ■ **Zak Storey**

Verdict

Great build quality; good-looking design; LED controller; authentic Cherry switches; USB passthrough.

★★★★☆

MECHANICAL KEYBOARD

$189 | GAMING.COOLERMASTER.COM

Cooler Master Quickfire XTi

A powerful, fully featured mechanical board with purdy colours.

Considering what you're getting is a full-size keyboard on your desk, complete with numpad, the XTi has a surprisingly-small footprint thanks to it's tiny bezel and lack of palm rest... though the latter might be off-putting to some people, depending on your typing style.

There's a channel on the underside of the board for cable management which allows you to route the removable 1.8m braided cable out the left-side, right-side or out the back, depending on your PC setup.

Individual key lighting and effects is a feature that usually makes me groan, but it's actually quite a cool and useful tool here, given you can save up to four individual settings and switch between them at will. So you could have a gaming setup with only the cricital WASD and surrounding keys illuminated, then switch to a one-colour, all-on setting for typing, or if you like purdy colours there's a sweeping

rainbow setting.

Macro keys are also programmable on-the-fly and playback speed can also be varied up to 8 times faster (than record speed) via a bank of keys up top.

Our review unit was fitted with Cherry Blue switches which feature a heavier feel and tactile click under the finger. The XTi is also available with the lighter (and much quieter) Cherry Brown, and Cooler Master tell us Red may become available if the demand is there.

Media and volume keys (nested into the home bank), n-key rollover and a Windows-key lock round out the XTi features. For the price, we would have liked USB passthrough, but it's definitely not a deal-breaker. ■ **Troy Coleman**

Verdict

A fully-featured extended mechanical keyboard for anyone who likes typing and colour.

★★★★☆

AWESOME THING

$250 | **SPHERO.COM**

BB-8 Droid by Sphero
A neat toy robot with real brains.

If you're one of the many *Star Wars* fans eager to catch the upcoming eighth film outing (*The Force Awakens*), you've probably crossed paths with the little rolling droid named BB-8 before. But there's something that differentiates this gizmo from the slew of other *Star Wars* paraphernalia out there: it's been built by the highly successful robotics startup Sphero. This company's speciality is app-controlled robotic balls and BB-8 represents an intriguing culmination of cinematic imagination and real world technology — some of which rarely comes to fruition this well.

BB-8's top-hat head floats on the droid's spherical body and is attached via magnets, making it completely removable — as you'll see if you ever drive it off the edge of a step. And though this miniaturized maglev technology is awesome to have in your very own toy, it's just one of the cool tricks BB-8 offers.

Like other Sphero robots, BB-8 is controlled via an iOS or Android app, which lets you manually control it using an easy-to-use virtual joystick. But the Jedi companion also has a mind of it's own and can be left on autopilot to patrol the house by bouncing its way around the uncharted terrain. Though Sphero has other products that allow robotics tinkerers to run their own algorithms through the robots, BB-8 has to run on the company's autopilot sequence — at least initially. Our favourite bit though: BB-8 draws on your smartphone to record and deliver augmented reality 'holographic' video messages using your smartphone's camera and screen.
■ **Joel Burgess**

Verdict
This animated droid is great fun, with a real personality.

★★★★☆

techradar.

The home of technology

techradar.com

software

Windows SOFTWARE

Ultimate Windows Tweaker 4

Make Windows 10 work the way *you* want.

FREE | TINYURL.COM/TLA43-UWT4

The arrival of Windows 10 means a whole new OS to explore, but among all those new elements are probably some bits and pieces that you won't love. The Ultimate Windows Tweaker (UWT) aims to iron out any personal rough spots by letting you quickly adjust a multitude of settings, many of which are otherwise buried away in obscure multi-level menus, or would require a registry edit to change. This is a great, straightforward utility that's well implemented, splitting all the tweaks up into individual areas and giving you a short summary of what each settings change does when you mouse over them. User privacy's been a big concern with Windows 10, so UWT's added some new options around this: if you're worried about Microsoft's more liberal data collection policy, you can easily disable the Telemetry options for both Windows and applications on UWT's Privacy page. While most of the app's tweaks here are safe as houses to apply, we'd still suggest creating a Restore Point before making any changes — and the big button down the bottom left makes doing so super easy. Dan Gardiner
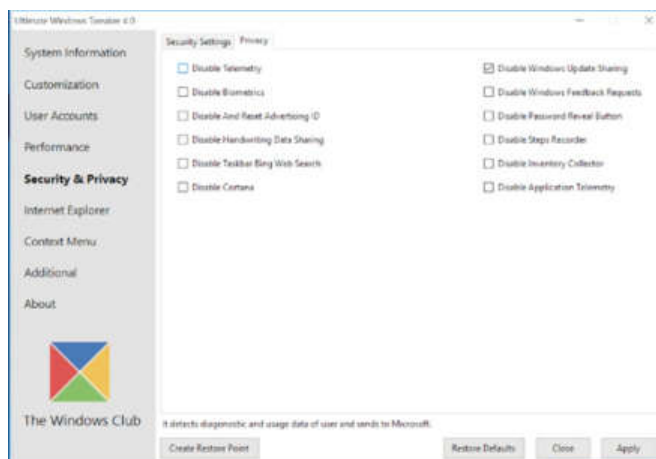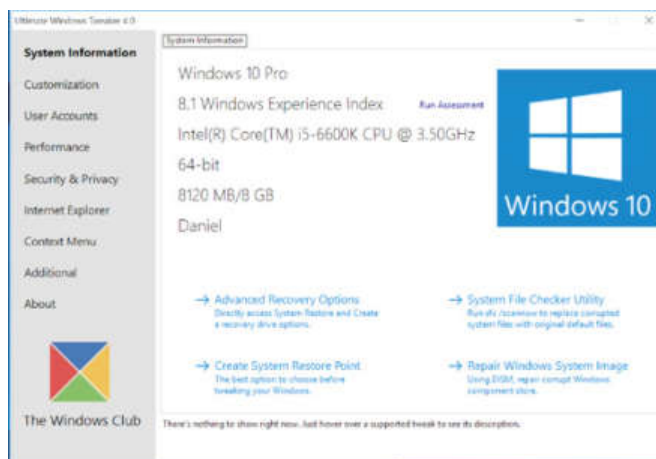
Microsoft Snip

Microsoft wants to give you the Snip.
FREE | MIX.OFFICE.COM/SNIP

For most of us, there probably isn't an urgent need for an upgrade to the the built-in Windows screenshot shortcut (Windows key-PrintScn). But if you like to share screenshots with others on a regular basis, then Microsoft Snip might be of interest. This app was only recently backed out of the Microsoft Garage and is still technically in beta, so you'll have to download it directly form the project page above. Once installed however, it integrates well into the Windows 10 desktop, with a little three option tab that hides at the top of the screen when you have the app running. From here you click on the selection tab, which brings up a cursor with a crosshair and a small magnifying glass, letting you draw a precise box around the area of the screen you want to capture. Additionally, if you run your cursor over a window it'll snap to it. After the initial snip you can do extra things like add in an audio recording, highlight text and draw on it as if it were a whiteboard, and then share or save the resulting video as a web page or an .mp4 file. If you're looking to capture a little more in your screenshots, Snip'll cut it.
Joel Burgess
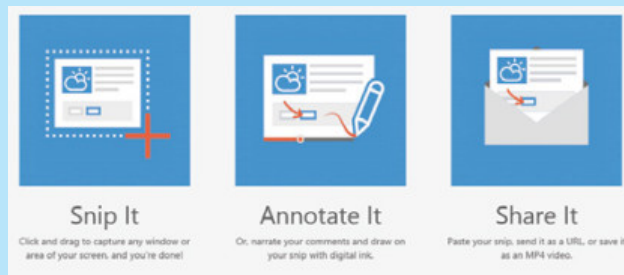
TechTool Pro 8

This diagnostic and repair tool just got even more useful

$99.99 | MICROMAT.COM

TechTool Pro has long been the go-to diagnostic, repair and recovery tool for your Mac, a potential lifesaver in just about any situation short of your Mac internally combusting. It's close to the complete solution, and version 8 packs in more tests while improving key aspects of the suite — such as integrating the portable ProToGo tool in the main interface.

The Tests section is overflowing with ways to monitor the health of your Mac, with the program now able to check just about any sensor in your Mac in addition to the core ones. Version 8 adds new tests for fans and MacBook batteries.

The Tools section remains largely unchanged — it's where you'll find the essential eDrive creator, which provides a recovery environment with access to all of TechTool's functionality should your Mac stop booting. You'll also find a number of repair and recovery utilities here, focussed mainly on your hard drive, but video and audio hardware too.

The suite is rounded off with its System Preferences Protection pane, which takes snapshots that can aid in data recovery. We also like the program's built-in disk imaging tools, which you'll need to use prior to any of these tools; though be aware some users have complained of data corruption. If you're an existing user, then TechTool Pro 8 is worth upgrading for the new tests alone.

The bottom line? TechTool Pro 8 is an essential buy for technicians and a potential lifesaver for the rest of us, to boot.
Nick Peers
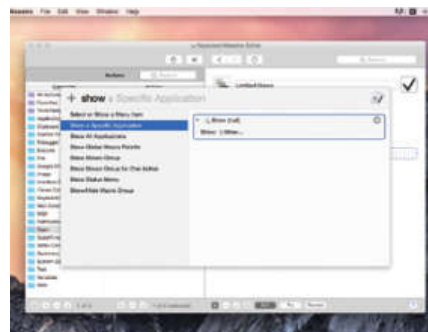
Keyboard Maestro
Press a couple of keys to do (almost) anything with your Mac
$53 | KEYBOARDMAESTRO.COM

Keyboard Maestro is all about controlling your Mac with user-defined macros, comprised of a trigger and one or more actions which range from simple hot-key commands through to more advanced interactions that can be based on specific conditions.

The app shows you how to set a function key to open your Home folder — simple. A more complex action is also provided which copies a selection, switches to the last used app, pastes, and then switches back again. Naturally, the sky's the limit once you get a handle on how to create your own macros.

Version 7 offers a range of new triggers and actions. Triggers now include keys tapped multiple times, window focus changes, and updates to folders. The last of those means you can be notified when new files are added to a shared folder. Actions have gained options that bring new smarts and complexity to macros, and it's good to also see the app making things easier for anyone creating them. There's a new gear menu in every action for access to contextual operations, an Add Action Bar for rapid access, and autocompletion of text and search tokens, functions and variables.

Keyboard Maestro still doesn't look especially pretty (the theme editor's palette styles come across as gaudy), but otherwise this is a solid update to a very capable app.
Craig Grannell
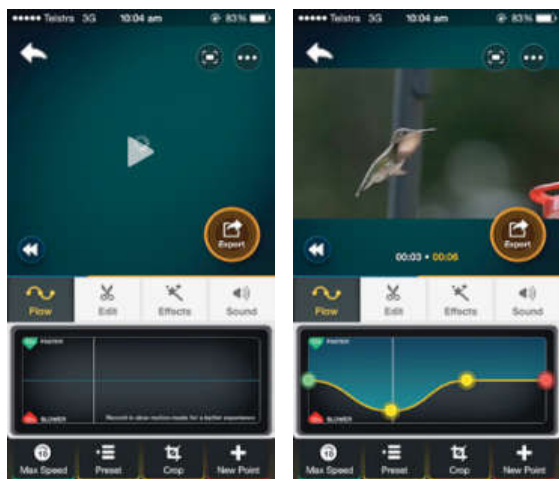
Flow - Fast and Slow Motion

Make videos at the pace you want. .

$2.99 | FLOWZERA.COM

Even if you're an excellent videographer, when you're shooting things like sports and animal footage sometimes the action just happens too quickly. There's a few free apps that specifically take slow-motion video, but if you want to tweak the speed of footage from other devices then you're going to need a video-editing app like Flow. Subtitled 'Fast and Slow Motion', this app is streamlined to focus on tweaking your video's speed. There are options to trim videos, add filters and layer a soundtrack over the top, but these tools are very basic; they'll help you finish off a video, but have notably less sophistication — even as a collection — than the app's speed-tweaking options. Considering you can add multiple speed points throughout the one video and you can edit each point to a sliding scale from ten times faster to ten times slower, if you want to make slo-mo vids this is a good option for a few bucks. Joel Burgess
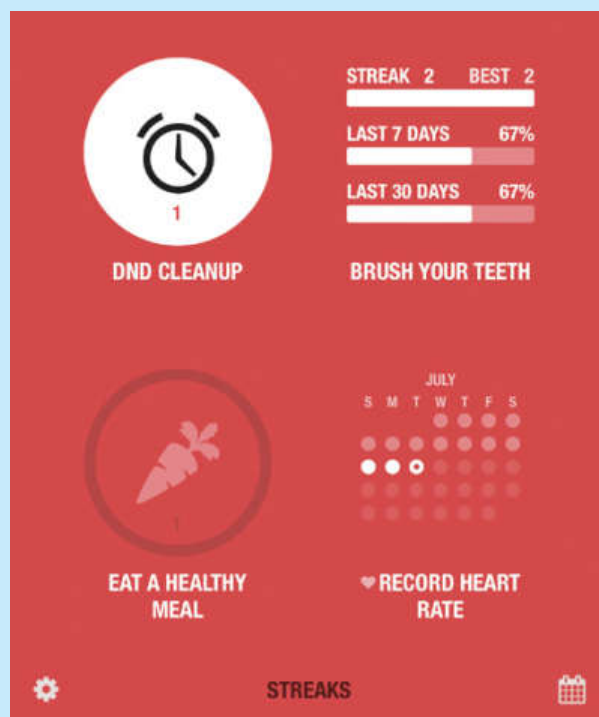
Streaks

Gamify your good intentions.

$4.99 | WWW.STREAKSAPP.COM

Streaks is a to-do list with a twist: you can only enter up to six tasks, which should be things that need doing regularly, so the app provides gentle encouragement by displaying how many times you've accomplished goals. But be careful: skip just once and your current streak is, firmly but fairly, reset to zero. If your tasks involve anything already tracked by HealthKit on iPhone or Apple Watch, Streaks can autocomplete those entries, sending a push notification to let you know. This feature came in handy for checking off our daily weight, steps and heart rate goals without even having to open the app. It's not useful for tasks performed more than once per day, or for those with more than six daily tasks, but otherwise fits the bill quite nicely. Streaks makes it fun and easy to keep tabs on up to six recurring tasks with a minimum of effort. JR Bookwalter

Fragment

Not your everyday image filtering app.

$2.49 | PIXITEAPPS.COM

Rather than making your images look like they've been left in a mouldy biscuit tin for 40 years, Fragment uses a geometric shape to split and duplicate the shot, creating a kind of double exposure. The menu allows you to switch the shape, as well as brightness, contrast, glow colour and even a stereoscopic 3D effect. It's the sort of thing you could spend hours playing with, and while it will repay the time you invest in it, sometimes the best results come from a simple application of the prism-like shards the app is capable of generating. The effects are certainly striking, but a lot rests on choosing the right combo of filter and image. New in this version is the ability to edit videos (in iOS 8). This works perfectly smoothly but is perhaps best saved for short sequences. Fragment isn't something you're going to want to apply to every photo. However, with the right image you can certainly create something special with it. Ian Evenden

Solid Explorer
Your files, displayed in style.
FREE WITH IAP | WWW.NEATBYTES.COM

Solid Explorer is a clean, well-presented file management system with simple but powerful features that give even more control over the files on your smartphone — though it depends on what version of Android you're using. If you're on 4.4, you might already be aware of limitations imposed if you've tried to delete a file when using a third party file explorer.

Getting rid of an old photo, for example, from within Solid Explorer might send you back to the default app to do so. Regardless of that, Solid Explorer offers a lot of flexibility and a clean, customisable display. Use your phone in a landscape orientation and you get two panes sitting side by side, perfect for easy copying. It'll also link to a plethora of cloud storage services, so it's a cinch to upload files from your device to Dropbox, OneDrive, Google, or your FTP, Mega account and so on, and it'll also handle Chromecast. **Paul Taylor**
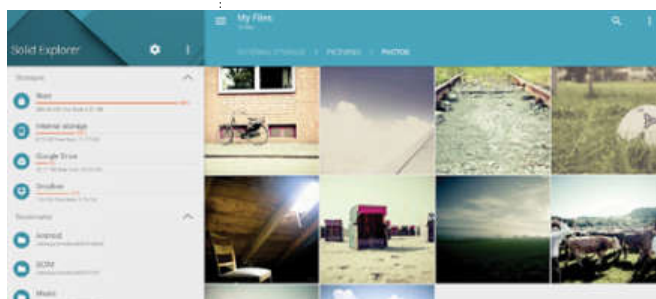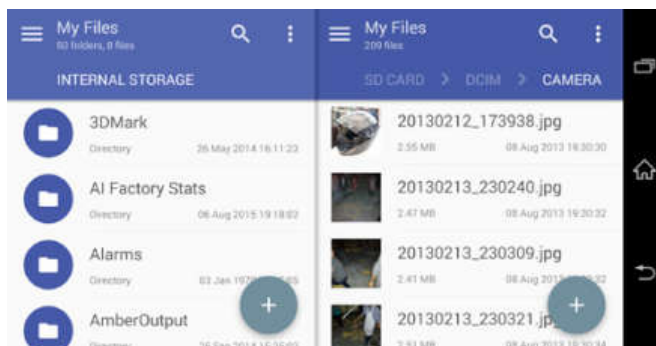
Opera Max
FREE | OPERA.COM

Are you stuck on a plan that offers a miniscule amount of data, but you're a fiend for bandwidth-hungry video and images whilst on your phone? Opera Max sounds like a good fit. Essentially it acts as an agent that goes in-between the source and your smartphone, reducing the bit-rate of videos and images to stretch out your data. The devs claim the app can extend your data plan by up to 50%, though it's a fuzzy claim at that, and you'll have to do your own comparisons to check just how well it performs based on your connection. Nor will it compress everything. Anything that's already compressed can't be squashed any further, nor will anything that comes from a secure connection (e.g. banking apps). However, all of your data runs through Opera's VPN, so if you're especially suspicious of apps seeing your online activity, maybe this isn't for you. Still, the interface is friendly and easy to use, providing time stamps of what apps are being used and when. **Paul Taylor**
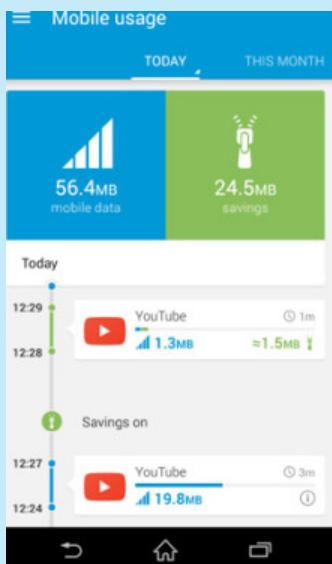
Instadict
FREE | TINYURL.COM/421INSTA

The instructions couldn't be clearer. Select a word in any app, copy it, shake your phone, and Instadict supplies the definition in an easy to read pane at the bottom of your screen. While Chrome offers an ability to search for words, it always needs to have an internet connection, pulls you away from what you're reading, and, well, it's only available in Chrome. Instadict is offline compatible, and keeps the screen open on what you're reading. There are compromises though. Its definitions are pulled from Wiktionary and some are extremely brief. Nor do they cover all word forms, and its presentation is inconsistent as some words with multiple uses have definitions for nouns, verbs and adjectives, most don't. However, as a quick go-to tool, it's a very clever and simple concept. Plus, it has a small footprint: the offline dictionary is under 18MB, and the app itself is a piddling 1.1MB. Now if only you could do that with magazines… **Paul Taylor**
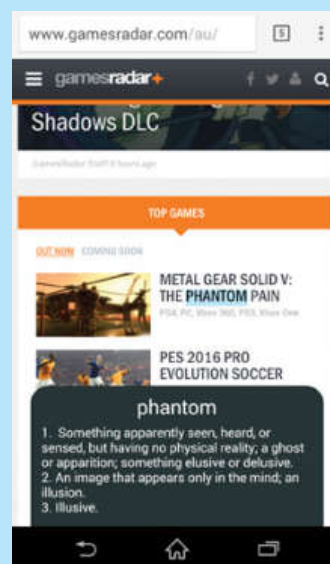
Instabullet
Shoot files between devices.
FREE; $1.59 | TINYURL.COM/APC421-IBULE

There isn't an official Pushbullet app for Windows Phone yet, but there's no shortage of third-party apps that offer one of Pushbullet's most sought-after features: flicking files back and forth between devices. Instabullet is an unofficial Pushbullet client that differentiates itself by claiming to have better file syncing than the competition. As a whole, Instabullet stacks up pretty well against other unofficial Pushbullet clients, but unfortunately it still lacks some of the features found in the official Android and iOS versions. You can log into your Pushbullet account through Instabullet, but there's no way to set up a Windows Phone device on a Pushbullet account and push files directly to it — you'll have to upload files to your Pushbullet cloud and pull them down through Instabullet later. If you don't have Dropbox and just need some way to flick files between your computer and Windows Phone quickly then this isn't a bad option, but we'd still prefer it if there was an official Pushbullet app. Then again, it's free and has no ads, so it's not a bad stop-gap while we wait.
Joel Burgess

Plex
A new Plex universe.
FREE | PLEX.TV

Though the rise of on-demand streaming services may at some point undermine the need for having your own home media, right now there's still an argument for having one central spot for your digital collections from which you can stream to various devices around your home — and Plex remains the standout program. Working in conjunction with a PC or Mac 'server' app, the company still considers Plex a beta application on the Windows Phone platform, even after the recently-released universal version for Windows Phone 8.1 and up. The upgrade brings with it a couple of notable features, along with a huge list of bug fixes. Attempting to align the smartphone app with the PC version, the devs also added in a media server and channel store to the selection menus. Upgrades to the storage visualisations and the method of syncing files adds further appeal to what was already a solid home media streaming app.
Joel Burgess
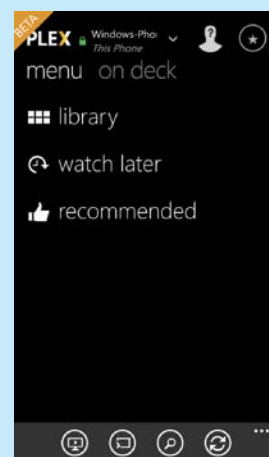
Surfy Browser
A serious IE/Edge competitor for Windows Phone.
FREE | TINYURL.COM/TLA43-SURFY

Other than Opera or CM Mobile, Windows Phone users don't really have any decent alternative browsers. And despite the fact that most mobile web traffic comes through direct apps, having a good browser specifically designed for your smartphone is still one of those core essentials. Surfy Browser is an impressive option. Available on Windows Phone for some time, in August the devs decided to make the app free (it was previously US$1.99) to coincide with a major update. In addition to a great tab function that pins your current web pages across the top of the browser and allows you to flick between multiple things quickly, Surfy features an easy-to-use hub page with favourites, tweakable settings and a downloads log page. Surfy Browser is also fast, allows you to configure your search engine of choice and has a decent list of sharable outputs, which all combine to make it an essential app for any serious Windows Phone user.
Joel Burgess
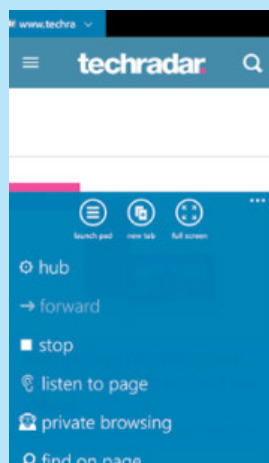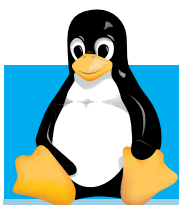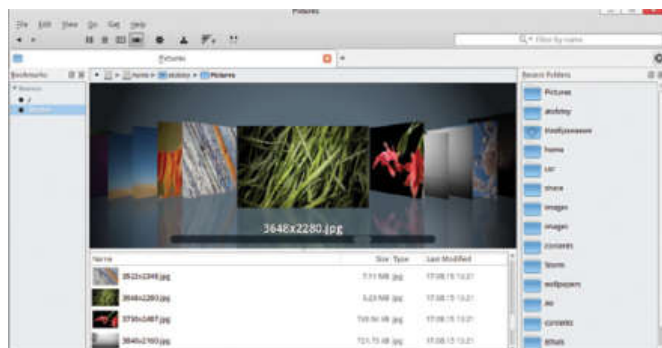
DFile Manager

A new way to manage your files.

FREE | DFILEMANAGER.SOURCEFORGE.NET

We first came across this file manager while surfing the endless ribbon on the DeviantArt website, with all its skins, themes and custom designs from the creative community. The DFileManager exterior looked just too good to be true, especially knowing that much of the cool eye-candy on the popular social network for artists tends to be mockups. But in the case of DFileManager, we have a beautiful and real application.

The source code is available at Github so that everyone familiar with Qt4/Qt5 and CMake can build it. We think that it's really worth trying too: first because there are virtually no binary packages for DFileManager, and second, because the application is functional and stylish.

Of course, there are plenty of file managers for Linux, and for KDE there's nothing better than Dolphin. But DFileManager uses a different layout with three columns and the Information bar below the columns. DFileManager tries to display as much useful information as possible without the root filesystem tree. As a result the file manager behaves more like the Finder found in OS X: with bookmarks on the left, the main browsing area in the centre and a dynamic Recent Folders bar on the right. Bookmarks work the same way as Places in Dolphin, and are also customisable.

The most attractive feature within DFileManager is the Cover Flow view, which isn't found in any other file manager for Linux. Cover Flow enables you to slide through items in the current folder with a smooth visual effect, which makes it very useful for browsing photos or any other objects that can be previewed.

DFileManager doesn't beat Dolphin in terms of available configurables, but it definitely has everything you'll need to change its behaviour and viewing options, including thumbnails generation and default startup options. DFileManager is a very capable tool with many features such as: onboard Terminal integration; ftp, sftp, scp and webdav support, filtering and more. **Alexander Tolstoy**

OwnCloud

FREE | OWNCLOUD.ORG

We really love OwnCloud, a personal file hosting solution that looks and feels like a remote cloud service. OwnCloud enables you to use the latest technology without compromising things that are beyond your control, such as data safety, privacy and the amount of disc space etc.

In order to run OwnCloud it's best to have a separate PC, which you can turn into a server. If you don't have one you can try out a personal cloud inside a virtual machine. Technically, you'll need: a MySQL database up and running; an NTP server for time sync; Apache web server and a bunch of PHP 5 dependencies for OwnCloud itself. It doesn't take much skill though and the process is aided by its comprehensive documentation.

When you do set it up, the localhost/owncloud address will open the OwnCloud web interface where you can create an account and log in. The web interface looks like a pretty standard CMS with a categories tree on the left-hand side and a current category content on the right.

OwnCloud supports lots of cool features, such as document preview and a thumbnail engine for almost anything (including fonts and RAW images), collaborative files editing, WebDAV access and much more.

OwnCloud can also can be extended with extra apps and synchronised with external services, such as Google Drive and Dropbox, and for playing music or showing content in a web-based file manager. The applications repository (repos) is extensive and is available at **apps.owncloud. com**. There's an endless list of possible uses for OwnCloud, such as web access from the internet, control from the Android app, file encryption, versioning and undeleting, LDAP and Active Directory integration etc.

The new 8.1 version promises faster file uploading and downloading, better control file encryption and the ability to edit office documents with WebODF, which supports annotations and handles more text styles.
Alexander Tolstoy
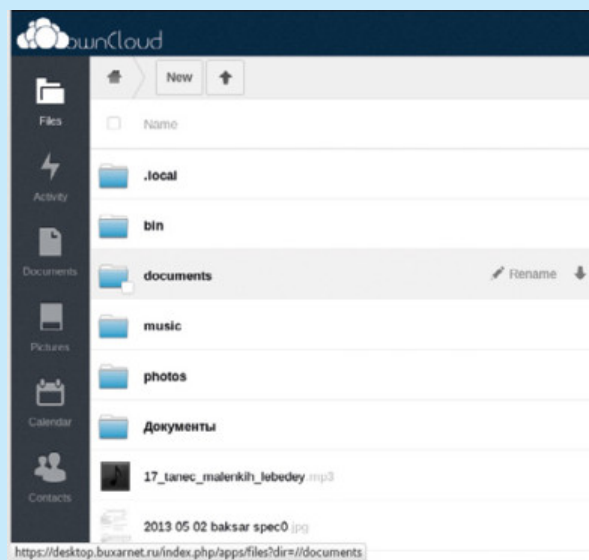
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The future of the GPU

It could be the perfect time to upgrade, but what do you need to prepare for the GPU future? Dave James and Lindsay Handmer find out.

The graphics card is the component most responsible for PC gaming performance. Above everything else in your PC. You could have the most powerful, $1,600 octo-core Haswell-E CPU in your rig, but if you've got a weedy GPU backing it up, you're never going to be hitting the graphical heights that today's PC games deserve.

And it's a great time to buy a new graphics card right now. Both the leading lights of GPU development — Nvidia and AMD — have finally released their graphics card lineups for this year, with high-end, ultra-enthusiast GPUs and super-efficient, lower-end offerings. And by the way, for ultra-enthusiast, read: eye-wateringly 'wtf-how-much?!' expensive.

While Nvidia has had it pretty much all its own way since the GTX 980 was released almost a year ago, AMD has finally responded with a slew of new — and some not so new — GPUs to try and put it back in the game. Correspondingly, Nvidia has updated its range and dropped the prices here and there. Who wins? We all do, of course. You can now go and bag yourself a quality, high-end graphics card for some pretty reasonable sums of money. Which is why this month we've got them all into one room for a GPU battle royale.

If this is the state of play in the graphics card market right now though, what does the future hold for this pedigree racehorse of components? Are we likely to have genuinely affordable, genuinely capable GPUs delivering the 4K feels on the next generation of high-resolution gaming monitors? And is the end nigh for the classic peripheral component interconnect express?

Both Nvidia and AMD are set for big new GPU architectures on incredibly tiny production processes in the next year, having both missed out on the bonanza that 20nm lithography was meant to offer. It's set to be a very intriguing time for the not-so-humble GPU then, and with the rise in screen resolution and the burgeoning VR industry's insatiable thirst for GPU power, it needs to be. Let's do some digging and see if we can figure it out what's going on…

Before we go too far into a future filled with high-bandwidth memory (HBM), new component interconnects and new GPU architectures, there are still a few holes to be plugged in AMD and Nvidia's respective graphics card lineups.

Landing just in time for this round-up is Nvidia's replacement for the GTX 750 Ti — the GTX 950. The GTX 750 Ti was the first Maxwell-powered graphics card and it makes sense for it to now be refreshed with new silicon. It's sporting a slightly cropped version of the GM 206 GPU, which is also found in the current GTX 960.

Like the GTX 750 Ti before it, the GTX 950 does offer some quite impressive levels of power efficiency combined with decent 1080p gaming performance, too.

To counter it, AMD is looking to try and spoil the low-end GPU party with its own Radeon 370X, a Trinidad GPU-powered card aiming squarely at the same price point as the GTX 950. It will essentially be using the same Pitcairn GPU that AMD filled the R9 270X out with, and it will be interesting to see who comes out on top in the battle at the bottom of the market.

There are also rumours that AMD is hard at work putting together a full range of HBM-supported graphics cards to follow the Fiji model used in the Fury cards. Whether that will be as part of an interim refresh of the current chips isn't known, but that's probably unlikely. We expect the current lineup to last until the next AMD GPU architecture drops next year some time.

BUT WHAT'S NEXT?

With the Maxwell GPU architecture having been around for a good long while now — since early 2014 with the GTX 750 Ti and from last September with the full-fat GTX 980 cores — it's time to start thinking about

The upcoming GTX 950 Ti could well come passively cooled.

The Nvidia Pascal demo board is some seriously small silicon.
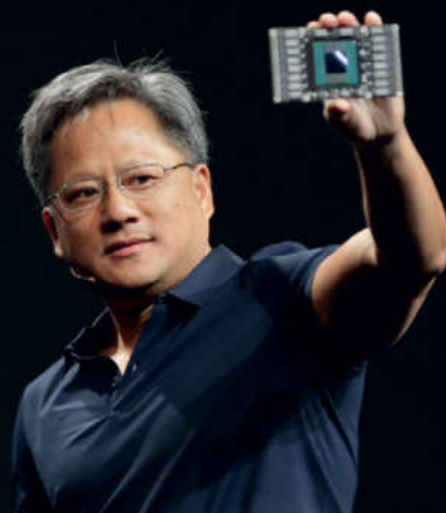
The next step for AMD's GPUs is to drop to the 16nm lithography.

Even the Titan X will look weedy against the 16 billion transistors of Pascal.

what's coming next.

The next generation of graphics cards from both Nvidia and AMD is going to see a major cut in the production process. This is the big news from the next round of GPU architecture updates, and also the reason for this current generation being something slightly different to what we originally expected.

When the two companies first started talking about their Maxwell and Pirate Islands GPU ranges, it was largely expected that these would be the first chips to tip up rocking the new 20nm production process. And it wasn't just us expecting that either — both the GPU makers thought they'd be making the move.

However, the 20nm process turned out to be a nightmare for the silicon makers to produce chips with at a consistent yield without losing a bunch to defective parts in the baking process. This made the whole 20nm lithography seriously expensive. Tied to the fact that it wasn't actually delivering much in the way of performance or efficiency gains, it's unsurprising that the switch wasn't deemed worth it.

So Nvidia and AMD have been stuck on the existing 28nm process for at least one generation longer than either really expected. Nvidia, however, seemed to see the writing on the wall, and, with the already-efficient Maxwell architecture, it was still able to deliver improved GPUs. AMD, on the other hand, has stuck with its existing architecture and simply piled more and more silicon into the design to boost performance.

But the new 2016 GPU architectures from AMD and Nvidia won't be on the 20nm process either. That ship has sailed and now we're expecting both companies to move their chip production process to the new 16nm FinFET (similar to Intel's Tri-Gate 3D transistors) lithography. This will allow far more transistors to be packed into the same, or smaller, die size and yield greater efficiency gains, too.

BLAISE OF GLORY
On the Nvidia side, we're looking at an architecture called Pascal — named after the French physicist Blaise Pascal — and the rumour that the successor to the full-fat GM 200 GPU could have as many as double the

transistor count. That would give it somewhere upwards of 16 billion transistors. That phrase needs to be read in your head one more time with Carl Sagan's wondrous tones.

The Pascal GPU will be the first of Nvidia's cards to offer 3D memory and is set to use the second generation HBM 2.0 to achieve the purported 32GB maximum frame buffer. One of the struggles with the current HBM tech used on AMD's Fiji cards is that it has a limit of 2Gb per DRAM die, making a maximum of 1GB in a stack, and only four memory stacks per GPU interposer. That's why the Fury cards have a slightly miserly, though speedy, 4GB frame buffer.

HBM 2.0 though is designed to massively boost that upper limit with a limit of 8Gb per die and stacks offering either four or eight dies piled on top of each other. That will give each stack a maximum of either 4GB or 8GB in capacity. With four of those HBM 2.0 stacks arrayed on the interposer around the GPU itself, you're looking at either 16GB or 32GB frame buffers, depending on the SKU.

Pascal is looking to unify its memory, too, making it available to both CPU

NVLink is going to be used between GPUs on our desktops.

Stacked, high bandwidth memory is the future of video memory.
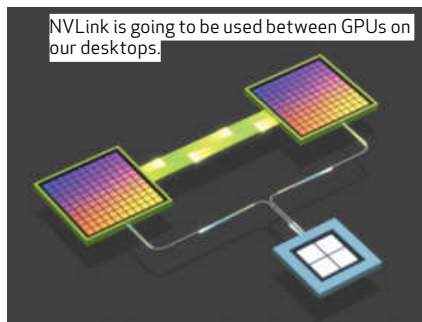
Is NVLink the end for PCIe?

Along with the announcement of the Pascal architecture, Nvidia CEO Jen-Hsun Huang also introduced the world to NVLink, an interconnect for its GPUs that could potentially offer between five and 12 times the bandwidth of the current PCIe 3.0 connection.

Nvidia's talking about NVLink offering DRAM-class speed and latency, which will allow for the use of Pascal's unified memory across the entire PC. It will also improve performance between GPUs, so multi-GPU systems could end up getting a far more linear scaling in terms of gaming speed.

As well as the NVLink connection on the GPU itself, it will also require dedicated silicon in the CPU if it wants to bypass the PCIe interface completely. From the outset though, that looks likely to be restricted to supercomputer-class high performance computing (HPC); Intel is unlikely to start dropping Nvidia silicon into its designs.

But if there's no path to the CPU, NVLink can just dedicate all its available bandwidth to GPU-to-GPU connections, which is what will potentially enable it to bear fruit in our gaming PCs.

Right now we're a fair way off saturating the available PCIe bandwidth on our rigs. The current interconnect is fine for our present-day needs, but boosting SLI scaling could be a real bonus. In terms of HPC applications, however, there are times when programs are doing large pro-level processing on the GPU — such as image processing for astronomy or seismic processing — and the PCIe interface becomes a serious bottleneck.

For our machines, that's not going to be a problem, and AMD shows no sign of wanting to shift interfaces either. We can't see PCIe going dodo any time soon, at least not in the next couple of years.
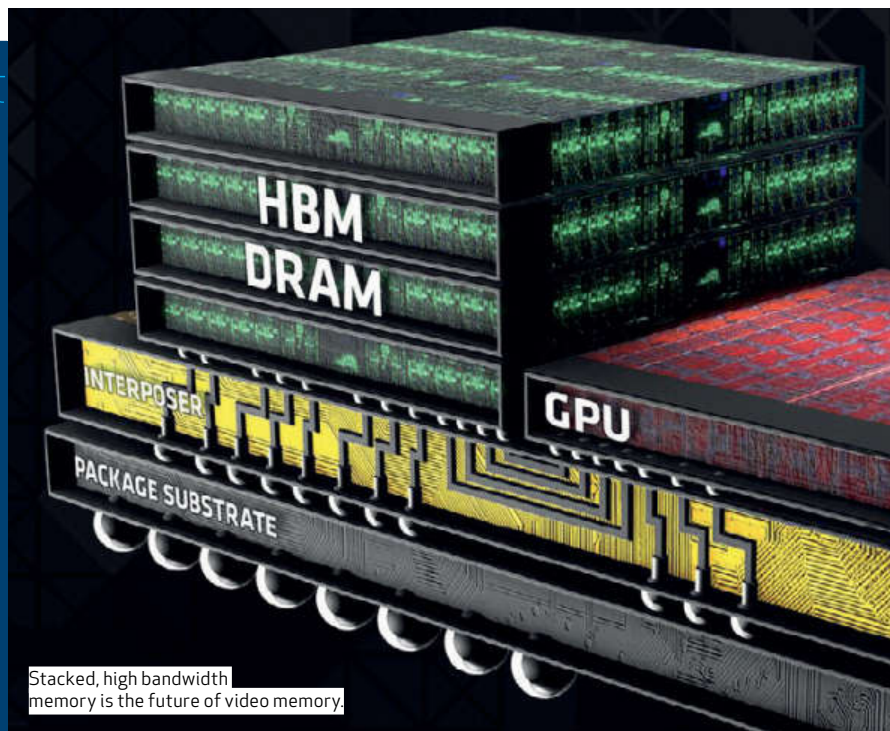
and GPU. In traditional interfaces, that would introduce latency issues across the PCIe connection when communicating between CPU and GPU. But with Pascal, Nvidia is introducing a new interface called NVLink. On our PCs, however, NVLink-proper looks a while off (see "Is NVLink the end for PCIe?", to the left, for more on that).

AMD ADVANCES

AMD's Arctic Islands architecture — also due in 2016 — could be AMD's first new GPU architecture since the inception of the Graphics Core Next design at the beginning of 2012. It has mentioned a doubling of the performance-per-watt efficiency of its high-performance range of GPUs.

It's unlikely to be too radical a departure from the current GCN architecture though, especially given mixing a new production process with a brand new architecture can be a recipe for disaster. Though that is also the route Nvidia is taking with Pascal…

What we do know is that the successor to the top Fiji GPU of today will have the Greenland codename and will sport the same second-gen memory architecture as the Nvidia cards — HBM 2.0. That will mean huge potential frame buffers all round. The Arctic Islands range will also utilise the 16nm FinFET technology, which is arguably how it's going to be able to nail the 2x perf-per-watt target that AMD has set itself.

With the introduction of the new lithography and the promise of high bandwidth memory being used throughout the GPU stack, we're pretty confident that Arctic Islands won't suffer from the same rebrand-a-thon woes that have somewhat blighted the current Southern Islands/R300 series release.

All in all, 2016 is looking a seriously exciting year in terms of graphics cards. The efficiency gains from the 16nm lithography will keep things highly chilled in the mid-range, but also allow for some absolute monster GPUs at the top end.

Hell, we could be looking towards 8K gaming by then, guys and gals. ∎

Sticking with a 28nm GCN chip requires some serious cooling.
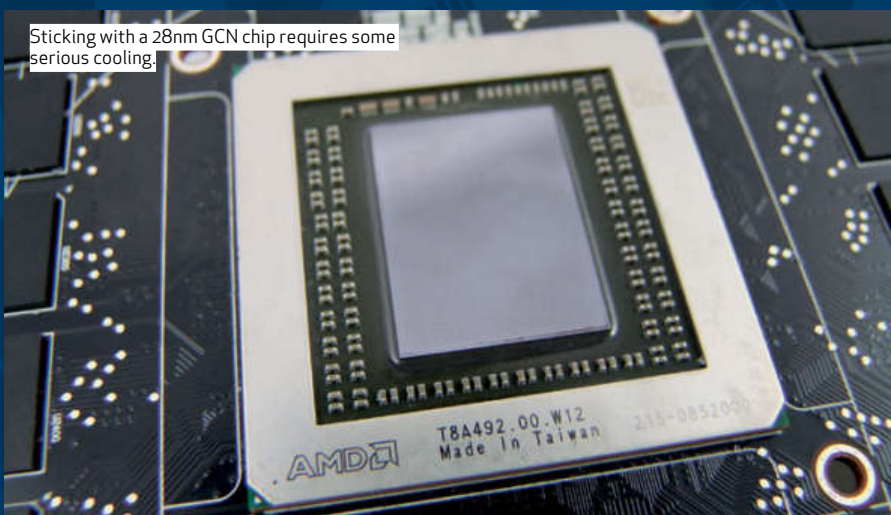
THE
MOST FUN
YOU CAN
HAVE WITH
YOUR HANDS
WITHOUT
GOING
BLIND

Card tested:
PowerColor Radeon
R7 360

$165 | WWW.POWERCOLOR.COM

AMD Radeon R7 360

Can this mid-range card really compete with Nvidia?

Released earlier this year, the Radeon R7 line brings some compelling options to the more affordable range of GPUs. The 360 uses the Tobago core, with fewer shading and texture mapping units, though running at higher frequencies than the 370. It's got 2GB of GDDR5 coupled to 768 stream processors for a 1536 GFLOP floating point performance. The core buzzes along at up to 1060MHz while the RAM hits 1650MHz (6500MHz effective). The card is rated at 100W and has a single 6-pin power connector. On the business end the card sports DVI, HDMI and DisplayPort — the latter of which can handle 4K video. Performance is decent for the price, but the card is aimed at 1080p gamers and will struggle with anything much higher unless the details are dialled back.

The problem with the R7 360 is that while it is just 73% of the price of the 370, it only offers 66% of the performance. Lower bang for buck is generally expected with budget cards, but the difference is enough that the extra $60 is a pretty worthy upgrade for most gamers. The real competition is from the older but almost identically priced GeForce GTX 750 Ti. The 750 is marginally more powerful, but the 360 is a tiny bit cheaper — though the difference is small enough not to matter in practice. Neither is well suited for the fastest frame rates at high resolutions — but the 360 has 20% or so more memory bandwidth which can help for some situations.

Verdict

A solid card, but it doesn't jump out as a great buy compared to the competition.

★★★☆☆
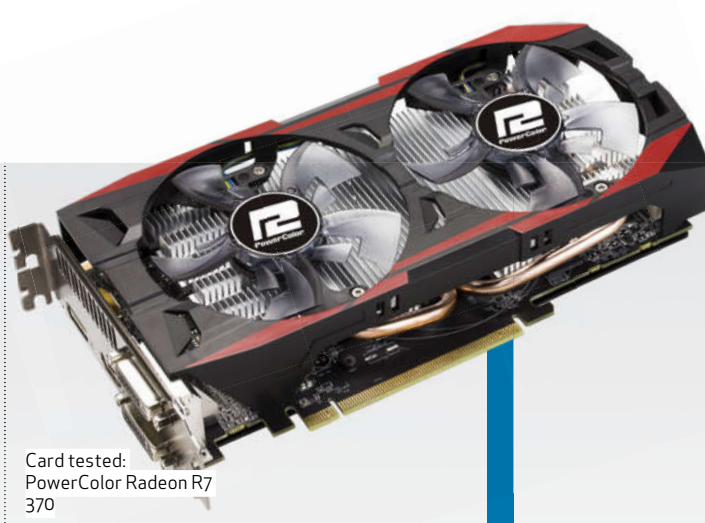
Card tested:
PowerColor Radeon R7
370

$225 | WWW.POWERCOLOR.COM

AMD Radeon R7 370

Offering better-value for money over some of the competition.

Sitting in a niche not occupied by any direct competition, the R7 370 skirts around the $200 mark and undercuts the GTX 950, while eclipsing the older 750 Ti. Under the hood it's a revamped Radeon R7 270 — which itself is an updated HD 7850. The videocard sports 2GB of GDDR5 RAM, with a 256-bit interface and a 1400MHz frequency. It's got 1024 stream processors and a core speed up to 975MHz. The whole kit and caboodle draws up to 110W and uses a single 6-pin power connector.

The 370 is aimed at mid-range gamers, and while it can do 4K resolutions, it's happiest at 1080p. Most modern games won't be a problem with the details on high, but be prepared to dial it back for some titles. One issue is that the 370 uses an older architecture, so does not support AMD FreeSync. The R7 370s closest competitor in green is the GTX 950, which is about 10% faster.

The good news is that the 370 is 15% cheaper — making it a good choice for those who want to save some money, albeit for a slight sacrifice in performance. The older 750 Ti is 73% of the cost, but only offers 66% of the performance — similar to the R7 360. There is also a 4GB version of the R7 370, but it's $30 - $40 more expensive. That puts in in competition with the GTX 950 (or almost the 960) — both of which are a better choice for the money.

Verdict

A well placed budget card with solid performance at 1080p.

★★★½☆

Card tested:
MSI GTX 950 Gaming

$269 | AU.MSI.COM

Nvidia GeForce GTX 950

Is it worth saving money over the older GTX 960?

With the Radeon R7 370 breathing down the GTX 960's neck, Nvidia released the 950 GTX as a slightly more budget offering. The 950 is based on the same GM206 silicon, with two fewer (6 vs 8) SSM units, 768 CUDA cores and the same 32 ROPs and 128-but memory bus. The MSI 950 tested is the overclocked Gaming variant, with a chunky Twin Frozr heat sink and a 1317MHz OC core clock.

The card comes with 2GB of GDDR5 slightly OC RAM (6650 vs 6610MHz, and don't expect a 4GB version) and can run up to four monitors at 4K, via the 3x DisplayPort connections, as well as DVI and HDMI. While the card boosts the core clock for gaming, it can also throttle back for a cool and quiet silent mode.

Performance is pretty much as expected — around 10% less than the 960, though the cut back card loses ground at very high resolutions. That said, it's not aimed at those wanting much more than 1080p — which it handles with aplomb.

The biggest problem with buying the GTX 950 is actually the GTX 960. Based on the cheapest few prices online, the 950 offers 90% of the performance for between 90% and 95% of the price of the equivalent 960. It would need to be at least $10 - $20 cheaper to offer better bang for buck. Of course your price mileage may vary — in which case the 950 is a solid buy if you can hunt up a good price.

Verdict

Saves a little money over the 960, but needs a further price drop to be truly compelling.

★★★☆☆

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apc
RECOMMENDS

Card tested:
MSI R9 380 Gaming 4G

$370 | AU.MSI.COM

AMD Radeon R9 380

Something old, something new.

We've given AMD a little bit of strife for the whole rebranding thing with this current generation of GPUs. And it does feel a little like the company is treading water until either TSMC or Global Foundaries get their 16nm acts together and provide it with a production process for the future. Which is all to say the R9 380 is another old-school GPU; though this is actually the second-most modern after the Fiji chips.

The Antigua GPU at the heart of the R9 380 is essentially the Tonga silicon from the previous generation. That means it's got the latest class of GCN architecture, rocking the same 256-bit memory bus as the R9 285 because of the lossless colour-compression tech boosting its memory performance.

That's some modern AMD goodness that's missing from the higher-end 390 cards. The real big win for this card is — and we know we keep harping on about it — the chunky memory buffer. With 4GB on this relatively low-end GPU, you're getting a quality 1080p gaming card that's more than capable of mixing it with the most graphically demanding games of now and tomorrow.

The 2GB buffer of the GTX 960 is what's holding it back, but with double that capacity, the R9 380 is a far more capable gamer, even offering very playable performance at 1440p too. Where you do need to be careful though is with the 2GB versions of the R9 380 that are floating around. Those are definitely to be avoided.

Verdict

A nice beefy buffer provides decent performance at 1080p, and the MSI cooler is great.

★★★★☆

apc
HOT PRODUCT

Card tested:
Sapphire R9 390 Nitro

$500 | WWW.SAPPHIRETECH.COM

AMD Radeon R9 390

Hawaii Pro, with added nitrous.

AMD always seems to pull off the same trick; release two cards based on only slightly different GPUs, with very slightly different performance numbers, and demand a lot more for one than the other.

Inevitably, we then look at the lower-spec card with almost the same gaming prowess and question why anyone would pick the pricier option. Such is the way with the Fury and Fury X. Such is the way with the 290 and 290X. And so it is with the 390 and 390X.

And when you throw into the mix that this new Sapphire Nitro branding means this overclocked card gets a Tri-X cooler attached to it, you know things aren't looking too good for the 390X. Couple all that with the fact the 390 also performs better than the top AMD GPU of the last generation and we have a great mid-ranger on our hands.

With most games you'll get excellent 1440p performance out of it, and for a pretty impressive price, too. That Sapphire cooler on this version means it maintains a chilled disposition even in the most aggressive of gaming arenas, and the 8GB frame buffer means it can take every high-res texture that *GTA V* or *Shadow of Mordor* cares to toss its way.

It may be another exercise in re-badging GPUs for AMD, but the little tweaks the team has made to this card's silicon have made it very much worth the effort. We may not be hugely impressed with the Fury, but the work it has done on the 390 almost makes up for it.

Verdict

Faster than the 290X and almost as quick as the 390X. Old architecture drops frames to the 970 though.

★★★★½

Card tested:
ASUS STRIX-GTX960-DC2OC-2

$300 | WWW.ASUS.COM/AU

Nvidia GeForce GTX 960

2GB of memory just ain't enough any more.

The GTX 960 is almost at the bottom of the ladder when it comes to the modern Maxwell lineup — the brand new GTX 950 is technically . And what that means is we're talking about a resolutely 1080p gamer's card.

You can, of course, run a 4K monitor from this GPU, but even at 1440p settings, you'll struggle to play the latest games at top settings with any semblance of buttery smooth gaming. Throw this ASUS STRIX card at anything running on a 1080p screen, though, and that's exactly what you'll get. *BF4* runs like a dream at top settings and you can get great performance out of *GTA V*, too. *Shadow of Mordor's* texture pack, though, is still seriously demanding, even at 1080p, so we only saw 36fps on average, which is still just about acceptable.

The big issue with this card is that 2GB frame buffer. Where once that was plenty, in this brave new resolution-heavy world of ours, it's simply not enough for the most demanding of games and is likely to leave you wanting when new titles drop in the big spring gamegasm.

But when it's coated in ASUS's STRIX armour, it's still a tempting sub-$400 GPU. The 0dB cooler only spins up when you get up to gaming speeds and even then this card stays seriously cool and quiet.

At this end of the market though, AMD has got it sewn up again. The competing R9 380 is similarly priced and rocks that 4GB frame buffer to give it some much-needed longevity.

Verdict

It's low-powered and decent at 1080p, but a weedy frame buffer fails at 1440p top settings.

★★★½

Card tested:
Gigabyte N970G1-
GAMING-4GD

$550 | **WWW.GIGABYTE.COM.AU**

Card tested:
XFX Radeon R9 390X

$620 | **XFXFORCE.COM**

Nvidia GeForce GTX 970

Ignore the shenanigans; this is the best of the mid-range.

There's genuinely a lot to like about the GTX 970, despite all the grumbling surrounding its offset frame buffer. It's a good gamer and comes at a decent price, too.

The issue is that Nvidia didn't disclose the smart work it had done with the GPU and the VRAM. To ensure it kept more of the actual GPU logic, Nvidia's engineers did some clever stuff splitting the frame buffer. Had it not done so, the chip would have lost a lot more of the good stuff. Unfortunately, it didn't disclose this and we saw games using over 3.5GB of VRAM struggling on the GTX 970.

But then this isn't a GPU you'd use for seriously taxing 4K gaming, anyways. You can get up there in the VRAM stakes with gaming at 1440p — *GTA V* and *Mordor's* texture packs do that — but elsewhere, the GTX 970 really fits the bill for a mid-range graphics card.

And Gigabyte's version comes with the excellent triple-fan Windforce cooler, which allows this card to be seriously overclocked without melting a hole in your motherboard. Even at its hottest, it doesn't top 64ºC.

Its biggest rival is that impressive R9 390. These two GPUs trade blows across most of our benchmarking suite, with AMD taking the lead in one test and Nvidia winning others. Where the 390 does win though is in the more modern games, which need over and above the 3.5GB / 4GB frame buffer this card is sporting, even at 1440p. That, and the fact the AMD card is cheaper, means we give the nod to the 390 here.

Verdict

Cool 'n' quick; decent price. Pricier than the 390; suffers at top settings in modern games.

★★★★☆

AMD Radeon R9 390X

Deserving of a new name?

It's really easy to get caught whining about feeling misled about this generation of AMD cards. The Fury cards and their Fiji GPUs are the only new graphics silicon AMD has really put the time into for this year's launch. Everything else is essentially a re-branded version of the last-gen option, with a few light tweaks here and there.

But those tweaks have made a real difference. While this Grenada XT GPU is little more than the Hawaii XT chip from the ol' R9 290X, AMD has squeezed a little more speed from its clocks — an extra 50MHz — and bundled in double the memory. Whether that's enough to mean the GPU deserves a new name is neither here nor there.

While the R9 390X is a lot quicker than the R9 290X it's replacing, it's also effectively the same price. Now, before we get ahead of ourselves, that 8GB frame buffer isn't going to suddenly deliver 4K gaming

performance for this ageing architecture — there's almost no difference between the 290X and 390X at the highest resolution — but it does deliver performance improvements almost across the board at lower levels.

Almost… because we did experience some weird issues with this card and *GRID 2*. But for everything else, even the demanding *GTA V*, it delivered impressive performance figures. Most obviously in the minimum frame rates, especially with Rockstar's modern classic.

But its little brother, the straight R9 390, is the issue here. It's practically as good, with a notable saving too.

Verdict

The hefty frame buffer delivers quality 1440p performance; but the R9 390 is almost as good.

★★★★☆

Card tested:
Sapphire R9 Fury Tri-X

$999 | **WWW.SAPPHIRETECH.COM**

Card tested:
AMD-supplied

$1,169 | **WWW.AMD.COM**

AMD Radeon R9 Fury

Fast and a little furious.

Such is the way with AMD graphics cards — they will almost always arrive two-by-two. When AMD creates a class of GPU, it will generally offer a higher-end XT version and a slightly cut-down Pro version.

The R9 Fury then is the slightly cut-down Pro version of the Fiji XT in the Fury X. The Fiji Pro has 512 fewer Radeon cores than its bigger brother, and a 50MHz drop in base clock, but is happily sporting the same 4GB of HBM for a super-speed frame buffer. It's also around $200 cheaper than the Fury X.

Which leaves us scratching our heads. This Sapphire, Tri-X-cooled version of the Fury actually clocks just 10MHz behind the Fury X and yields almost identical gaming frame rates as the more expensive, water-cooled reference card. Yes, the air-cooled card inevitably runs hotter — by around 15 degrees — but when you're dropping only a few fps on average, but saving $200, it becomes a bit of a no-brainer.

It's still over $800 for effectively a third-tier graphics card, but it will deliver excellent gaming performance and, if you're not going 4K yet, will make your 1440p screen sing. The Fury also goes toe-to-toe with the 980, often taking a performance lead. That has led to some price drops on the older card though, so you can find great deals on the Nvidia side now. But when the price is close, we'd recommend staying with the more-advanced card that's rocking HBM if you're chasing a purchase.

Verdict

Almost as quick as the Fury X with sedate cooling, but it's expensive and only just faster than 980.

★★★★½

AMD Radeon R9 Fury Nano

A mini card looking to enable 4K gaming in the lounge room.

High-end graphics cards and cool, quiet media PCs don't really go hand in hand — that is until the AMD boffins got involved. The R9 uses the same architecture and 4096 shaders as the flagship Fury X GPU, but squeezes it down to a half-length, (thin) double width card that can fit in a mini- or micro-ITX case.

The Fury Nano is all about efficiency, and limited to just 175W — a far cry from the 275W of its bigger brother, the Fury X. Technically the Nano can't actually reach the full potential its Fiji core is capable of — instead the card is constrained by heat output. To compensate, the Nano uses silicon binned for efficiency and reins in the clock speeds slightly, giving 10% less performance for up to 36% less power consumption. To compare to the last-gen R9 290X powerhouse, the Nano is 30% faster while using 30% less power.

While performance varied across different benchmarks and games, the Nano does what it says on the tin. Overall we saw about 11% less performance than the Fury X — albeit for a very similar price. The Nano is a great choice for 4K living room gaming, and is amazingly cool and quiet considering how much graphics grunt it outputs.

Of course the Nano is still very new and prices are high, so it's hard to compare exactly how much extra you are paying for the form factor. Ultimately though, there is no other graphics card out there which can offer such high-end performance in a tiny and efficient package.

Verdict

Compact, efficient and expensive gaming power like no other.

★★★★☆

Card tested:
AMD-supplied

$1,200 | WWW.AMD.COM

Card tested:
Palit GTX 980
JetStream

$700 | WWW.PALIT.BIZ

AMD Radeon R9 Fury X

Full of sound and fury.

We genuinely had high hopes for the Fiji GPU in the latest Pirate Islands range of flagship AMD graphics cards. And then the tantalising promise of the first sub-28nm GPU vanished along with the 20nm process it was supposed to use, leaving us with just the hopes that high bandwidth memory (HBM) might lift this new Radeon high enough to compete with Nvidia's finest.

The struggle with Fiji is that, to all intents and purposes, it represents very little advancement from the previous generation of Graphics Core Next chips. It's just got a lot more logic inside it. If that had been paired with the die-shrink, things might have been rosey. As it is, the 28nm GPU generates a lot of heat (note the water cooler on the vanilla reference board). Even with the huge 4,096 Radeon cores inside, it can't perform as well as the slightly more expensive reference GTX 980 Ti.

It has got the first generation of HBM in there — that's allowed for the smaller form factor, but seemingly little else at the top resolution. At 1440p and 1080p you get a nice uplift over the old Tahiti-powered R9 290X, but when you hit 4K, that 4GB frame buffer just runs out. Because of the limits of first-gen HBM, AMD could only fit 4GB onto the Fiji GPU.

With hugely detailed games such as *Middle-earth: Shadow of Mordor*, *Total War: Attila* and *GTA V* demanding well above that limit, the Fury X quickly bumps into its performance ceiling.

Verdict

Water cooling and next-gen memory can't quite catch the GTX 980 Ti.

★★★½☆

Nvidia GeForce GTX 980

Bon anniversaire, old fella.

It seems funny to think the GTX 980 is almost a year old. It doesn't seem that long since we first plugged the big Maxwell chip into our test rig and were blown away by the unprecedented mix of performance and efficiency.

Despite still being built of the same 28nm transistors as the Kepler generation of graphics cards, Nvidia had managed to tweak its architecture enough that you effectively got all of the benefits of a die-shrink, without having one. Imagine what it would've been like had Maxwell hit the 20nm lithography we expected. Imagine what Pascal is going to be like when it arrives next year.

A year down the line, the 980 is still a great card, especially since the release of the Fury and Fury X has encouraged its first real price drop. With this outstanding Palit card being almost $200 cheaper than the Fury — and a great deal less than the Fury X — it's a fantastic GPU for your 1440p gaming rig.

The GPU here is seriously overclocked, as the GTX 980 is generally capable of, and comes with a 0dB cooler that only really needs to kick in at peak gaming performance.

Right now though, 1440p is the limit of the 4GB frame buffer the GTX 980 sports. So 4K gaming is possible, but too much of a compromise for this card. It's a toss-up between this and the Fury, and in the end it's going to come down to finances and personal preference. The Fury is quicker and has superior memory tech, but the GTX 980 is cheaper and less power hungry.

Verdict

Still a great GPU with quality cooling and sterling 1440p perf. This ain't a 4K card though.

★★★★☆

APC RECOMMENDS

Card tested:
ASUS STRIX-GTX980TI-
DC3OC-6GD5-GAMING

$1,149 | WWW.ASUS.COM/AU

Nvidia GeForce GTX 980 Ti

Factory overclocked for high-end performance.

The GTX 980 Ti uses a very slightly trimmed down version of the GM200 Core in the mighty Titan X — with 2816 CUDA cores instead of the full 3072. It's got the same 96 ROPs and 384-bit memory bus, but 6GB of RAM instead of 12GB. It's also a good $400 cheaper — but is it worth the savings?

With this card, ASUS has taken the GTX 980 Ti and enhanced the voltage regulation, improved the cooling and then just overclocked the bejesus out of it. The result is a 1317MHz core frequency (up from 1000MHz), which gives a 15% - 25% performance boost over the stock card, depending on game and resolution.

Not surprisingly, the Strix can outperform a stock Titan X, despite costing 25% less. Overclocked versions of the more expensive bigger brother are still faster of course (especially at higher res), but can be even more expensive again.

Essentially though, the Strix can handle whatever game you care to play at up to 4K resolution, and will continue to do so for quite some time.

In normal use the card is super quiet thanks to the large, slow spinning fans, though our test card exhibited a bit of coil whine, but nothing loud enough to be an issue inside an actual case.

The card has DVI, HDMI and three DisplayPort outputs plus some funky LED lighting. The Strix also comes with software that makes it easy to control to tweak the card further, or automatically dial it back or run super cool when not gaming.

Verdict

It's expensive, yeah, but this is arguably the card to get for 4K gaming.

★★★★☆

Card tested:
Nvidia-supplied

$1,600 | WWW.NVIDIA.COM

Nvidia GeForce GTX Titan X

Not winning this clash of cards.

Nvidia's GTX Titan X is the pinnacle of today's graphics card technology, a position it's likely to maintain until Pascal tips up, waving its 16nm transistors all up in the GM 200 GPU's silicon face. But that doesn't make it the best card around.

At launch, the $1,600 price tag seemed insanely, almost offensively, high. Sure, it was the first time we'd seen the much-vaunted GM 200 GPU appear in a form we could jam into our desktop machines, and it is most definitely head and shoulders above the GTX 980 in terms of gaming performance, but it didn't have the same feel as the original Titan.

Lacking the supercomputer, double-precision capabilities for a start, we never warmed to the black shroud of the 'X' either. The big problem, however, is that card sitting nonchalantly to its left — the GTX 980 Ti.

It was always going to happen. GPU history has taught us that much. But the release of the GTX 980 Ti has rendered the Titan X almost entirely irrelevant. The higher clockspeeds of most iterations of its younger sibling made the difference between core count vanish, and often delivers the GTX 980 Ti a performance lead.

And yet, the Titan X is still almost $400 more expensive, only buying you an extra 6GB on top of the GTX 980 Ti's frame buffer. By the time you need 12GB of graphics memory, the next generation of mid-range GPU tech may well be making this ol' ultra enthusiast card look tired.

Verdict

The huge frame buffer and high overclockability are nice, but it doesn't offer great value.

★★★☆☆

WHAT WOULD STEVE DO?

HOW WE TESTED

Our test rig comprises an Intel Core i7-5960X in an ASUS X99-Deluxe motherboard with 16GB of 2,133MHz DDR4 memory under Windows 8.1.

All of the graphics cards are tested with the latest release drivers on the same benchmark settings to ensure a fair test.

We've included the minimum frame rate results as well as the overall average to indicate how smooth an experience you're getting from each graphics card. Game results are all minimum/average fps.

SPECIFICATIONS

	WEBSITE	PRICE	GPU	CORES	MEMORY CAPACITY	MEMORY BUS	TDP	PEAK TEMPERATURE °C
AMD RADEON R9 360 (POWERCOLOR RADEON R7 360)	WWW.POWERCOLOR.COM	$165	BONAIRE	768	2GB GDDR5	128-BIT	90W	81
AMD RADEON R9 370 (POWERCOLOR RADEON R7 370)	WWW.POWERCOLOR.COM	$225	PITCAIRN	1024	2GB GDDR5	256-BIT	110W	80
AMD RADEON R9 380 (MSI R9 380 GAMING 4G)	AU.MSI.COM	$370	ANTIGUA	1,792	4GB GDDR5	256-BIT	190W	78
AMD RADEON R9 390 (SAPPHIRE R9 390 NITRO)	WWW.SAPPHIRETECH.COM	$500	GRENADA PRO	2,560	8GB GDDR5	512-BIT	275W	71
AMD RADEON R9 390X (XFX R9 390X)	WWW.XFXFORCE.COM	$620	GRENADA XT	2,816	8GB GDDR5	512-BIT	275W	80
AMD RADEON R9 FURY (SAPPHIRE R9 FURY TRI-X)	WWW.SAPPHIRETECH.COM	$999	FIJI PRO	3,584	4GB HBM	4,096-BIT	275W	79
AMD R9 FURY NANO	WWW.AMD.COM	$1,169	FIJI	4,096	4GB HBM	4,096-BIT	175W	81
AMD R9 FURY X	WWW.AMD.COM	$1,200	FIJI XT	4,096	4GB HBM	4,096-BIT	275W	64
NVIDIA GEFORCE GTX 950 (MSI GTX 950 GAMING 2G)	AU.MSI.COM	$269	GM 206	768	2GB GDDR5	128-BIT	90W	70
NVIDIA GEFORCE GTX 960 (ASUS STRIX-GTX960-DC2OC-2GD5)	WWW.ASUS.COM/AU	$300	GM 206	1,024	2GB GDDR5	128-BIT	120W	64
NVIDIA GEFORCE GTX 970 (GIGABYTE GV-N970G1 GAMING-4GD)	WWW.GIGABYTE.COM.AU	$550	GM 204	1,664	3.5 + 0.5GB GDDR5	256-BIT	145W	64
NVIDIA GEFORCE GTX 980 (PALIT GTX 980 SUPER JETSTREAM)	WWW.PALIT.BIZ	$700	GM 204	2,048	4GB GDDR5	256-BIT	165W	75
NVIDIA GEFORCE GTX 980 TI (ASUS STRIX-GTX980TI-DC3OC-6GD5-GAMING)	WWW.ASUS.COM/AU	$1,149	GM 200	2,816	6GB GDDR5	384-BIT	375W	69
NVIDIA GEFORCE GTX TITAN X	WWW.NVIDIA.COM	$1,600	GM 200	3,072	12GB GDDR5	384-BIT	250W	83

1,920 x 1,080 BENCHMARKS (1080P)

	BATTLEFIELD 4	TOTAL WAR: ATTILA	GRID 2	GTA V	SHADOW OF MORDOR
AMD RADEON R9 360 (POWERCOLOR RADEON R7 360)	21 / 33	6 / 15	38 / 47	8 / 21	WNR
AMD RADEON R9 370 (POWERCOLOR RADEON R7 370)	22 / 41	7 / 15	57 / 71	8 / 25	14 / 38
AMD RADEON R9 380 (MSI R9 380 GAMING 4G)	34 / 53	11 / 18	73 / 87	12 / 48	18 / 45
AMD RADEON R9 390 (SAPPHIRE R9 390 NITRO)	47 / 82	21 / 30	91 / 118	20 / 74	38 / 79
AMD RADEON R9 390X (XFX R9 390X)	48 / 90	18 / 31	62 / 77	21 / 78	40 / 83
AMD RADEON R9 FURY (SAPPHIRE R9 FURY TRI-X)	61 / 97	28 / 37	100 / 134	31 / 85	29 / 93
AMD R9 FURY NANO	55 / 101	27 / 33	98 / 135	28 / 87	45 / 95
AMD R9 FURY X	60 / 100	29 / 39	114 / 146	10 / 88	47 / 98
NVIDIA GEFORCE GTX 950 (MSI GTX 950 GAMING 2G)	27 / 54	10 / 21	64 / 81	11 / 37	14 / 33
NVIDIA GEFORCE GTX 960 (ASUS STRIX-GTX960-DC2OC-2GD5)	31 / 55	9 / 18	71 / 88	9 / 49	17 / 36
NVIDIA GEFORCE GTX 970 (GIGABYTE GV-N970G1 GAMING-4GD)	47 / 90	21 / 30	104 / 131	21 / 75	50 / 74
NVIDIA GEFORCE GTX 980 (PALIT GTX 980 SUPER JETSTREAM)	62 / 113	23 / 36	129 / 162	21 / 87	42 / 89
NVIDIA GEFORCE GTX 980 TI (ASUS STRIX-GTX980TI-DC3OC-6GD5-GAMING)	84 / 141	37 / 42	118 / 195	22 / 126	44 / 121
NVIDIA GEFORCE GTX TITAN X	64 / 122	21 / 43	132 / 180	12 / 103	49 / 108

2,560 x 1,600 BENCHMARKS (1600P)

	HEAVEN	BATTLEFIELD 4	TOTAL WAR: ATTILA	GRID 2	GTA V	SHADOW OF MORDOR
AMD RADEON R9 380 (MSI R9 380 GAMING 4G)	11 / 23.6	25 / 39	7 / 12	46 / 57	11 / 34	10 / 35
AMD RADEON R9 390 (SAPPHIRE R9 390 NITRO)	15.9 / 37.8	34 / 58	13 / 20	70 / 88	15 / 52	28 / 56
AMD RADEON R9 390X (XFX R9 390X)	16.7 / 38.8	35 / 61	14 / 21	62 / 77	17 / 55	29 / 58
AMD RADEON R9 FURY (SAPPHIRE R9 FURY TRI-X)	19.8 / 46.9	40 / 69	18 / 25	82 / 105	16 / 61	32 / 67
AMD RADEON R9 FURY NANO	19 / 67.4	32 / 69	15 / 31	79 / 101	13 / 50	32 / 63
AMD RADEON R9 FURY X	19.4 / 49.9	36 / 73	18 / 27	90 / 111	10 / 62	35 / 71
NVIDIA GEFORCE GTX 960 (ASUS STRIX-GTX960-DC2OC-2GD5)	10.5 / 23.1	23 / 37	6 / 11	48 / 59	6 / 31	14 / 24
NVIDIA GEFORCE GTX 970 (GIGA-BYTE GV-N970G1 GAMING-4GD)	15.4 / 38.4	34 / 57	13 / 19	76 / 96	19 / 49	38 / 51
NVIDIA GEFORCE GTX 980 (PALIT GTX 980 SUPER JETSTREAM)	18.2 / 48.6	42 / 73	13 / 23	93 / 118	16 / 57	36 / 61
NVIDIA GEFORCE GTX 980 TI (ASUS STRIX-GTX980TI-DC3OC-6GD5-GAMING)	18.9 / 71.3	67 / 88	20 / 32	121 / 161	14 / 72	49 / 88
NVIDIA GEFORCE GTX TITAN X	19.8 / 60.4	46 / 83	19 / 28	105 / 1386	7 / 70	48 / 74

3,840 x 2,160 BENCHMARKS (4K)

	HEAVEN	BATTLEFIELD 4	TOTAL WAR: ATTILA	GRID 2	GTA V	SHADOW OF MORDOR
AMD RADEON R9 390 (SAPPHIRE R9 390 NITRO)	9.3 / 16.4	17 / 30	6 / 10	41 / 52	12 / 26	17 / 31
AMD RADEON R9 390X (XFX R9 390X)	9.5 / 17.3	19 / 31	6 / 10	44 / 55	12 / 28	22 / 31
AMD RADEON R9 FURY (SAPPHIRE R9 FURY TRI-X)	10.8 / 21.3	23 / 38	7 / 12	50 / 66	1 / 33	14 / 36
AMD RADEON R9 FURY NANO	10.4 / 20.1	20 / 37	WNR	55 / 77	1 / 32	16 / 34
AMD RADEON R9 FURY X	11.6 / 22.7	21 / 40	3 / 12	57 / 70	3 / 35	18 / 38
NVIDIA GEFORCE GTX 970 (GIGA-BYTE GV-N970G1 GAMING-4GD)	9.2 / 16.2	17 / 29	4 / 9	39 / 54	12 / 24	19 / 27
NVIDIA GEFORCE GTX 980 (PALIT GTX 980 SUPER JETSTREAM)	10.3 / 20.6	23 / 38	6 / 11	46 / 67	6 / 23	26 / 33
NVIDIA GEFORCE GTX 980 TI (ASUS STRIX-GTX980TI-DC3OC-6GD5-GAMING)	13.9 / 28.7	30 / 52	10 / 14	77 / 88	9 / 45	34 / 56
NVIDIA GEFORCE GTX TITAN X	17.5 / 26.5	25 / 43	6 / 14	59 / 78	11 / 36	29 / 38

Screen screamers

Ashton Mills puts 10 blistering, high-framerate and super-smooth gaming screens to the test.

We're spoilt for choice when it comes to gaming monitors today — up to 144Hz and with G-Sync or FreeSync, games have never looked so good. So what separates a 'gaming monitor' from your normal display? Usually, one or more of the following:

120HZ/144HZ

Playing games at 120Hz or 144Hz allows you to play them at 120fps or 144fps, and with twice the frequency of updates everything feels more fluid, smoother, and life-like on-screen. Even something as simple as scrolling in your browser is smoother. The one caveat is this: you need enough GPU power to power this.

G-SYNC

Usually when a PC can't push frames fast enough to match the display, tearing will occur where frames overlap each other. Alternatively Vsync can be enabled, however this works by synchronising the GPU to the display, which can cause a drop in the refresh rate (such as going from 60 to 30fps) until the GPU load eases. G-Sync aims to solve this by synchronising the display to the GPU, and dynamically adjusting the refresh rate. The result is a smoother experience with Vsync enabled, sometimes making games quite playable as low as 40fps. However if you stay above your monitor's refresh rate (such as 60fps on a 60Hz), G-Sync doesn't kick in. Note that G-Sync is Nvidia proprietary and only works with Nvidia cards, and requires a hardware module that adds to the monitor's cost.

FREESYNC

FreeSync is AMD's equivalent and operates in much the same way, and requires an AMD card to use. One key difference however is that AMD's FreeSync utilises VESA (the industry body that defines display standards) Adaptive-Sync, now part of the Display Port 1.2 standard (VESA adopted Adaptive-Sync from FreeSync, just to confuse things). This is of note as Adaptive-Sync is open for anyone to use, including Nvidia, and as a result Nvidia has received criticism for pushing its own closed solution. Additionally, FreeSync/Adaptive-Sync doesn't require an extra hardware module so doesn't increase the cost of a monitor. Note that G-Sync and FreeSync require DisplayPort 1.2.

Other features are sometimes included, though often added more as marketing incentives: overdriving can reduce ghosting, though it may introduce visual artifacts; gaming profiles that set monitor parameters such as FPS or RPG modes, however in practice it's usually better to set your own settings; 'shadow boosting' that adjusts contrast to make enemies more visible, though it can wash out an image; and 'crosshairs' that simply overlay a crosshair in the centre of your screen. Don't buy a monitor for any of these features, concentrate instead on image-quality, resolution, and price.

Much like every other purchase, you get what you pay for. IPS is hands-down better than TN for contrast, colour reproduction, and viewing angles. If you can afford it, get it. Same can be said for screen size and resolution. A larger screen and a higher resolution means you can fit more into your screen and get more done, or from a gaming perspective be more immersed with a greater level of detail. Just remember higher resolutions require more GPU grunt to drive.

Beyond budget your purchasing process should be: determine your preferred size of monitor (24-inch, 27-inch, 34-inch and so on), determine your preferred resolution, and then decide whether image quality or a high response time is more important. You will find more TN-based panels reaching 144Hz than IPS, but the holy grail is to have both. Then look at G-Sync or FreeSync depending on your GPU. Finally check the ports on offer. Most monitors will sport DVI, HDMI and DisplayPort, but this isn't a strict rule.

Enabling G-Sync and FreeSync respectively on Nvidia and AMD cards.

apc
✓✓✓
RECOMMENDS

Acer XR341CK

Big and beautiful, with a price tag to match.

Acer's XR341CK is a gloriously large, ultra-wide, 21:9 34-inch monitor that's hard not to like when it wraps its cuved screen around you. Add to this it's an IPS-based panel with fantastic contrast and rich colours that's a pleasure to use. And on top of this you've got 3,440 x 1,440 pixels, providing a superb level of detail, all with a 4ms response time.

Well, you can't have everything. The maximum refresh is 75Hz, but it's also FreeSync, though here we ran into a problem: with FreeSync enabled everything was silky smooth as expected, but when disabled the image visibly skipped frames, and this for solid Vsync-ed output well above 75fps. We tested this on both Nvidia and AMD GPUs with the same result, and as FreeSync is AMD only this makes the monitor off the books for Nvidia users. Considering the other FreeSync monitors didn't have this issue, it's specific to this model.

A design flaw also places the DP port directly beneath the chassis overhang, necessitating a screwdriver to depress the plug's clip to detach it. Adding to its woes, the 'gaming' preset modes elicited a high buzzing noise from the monitor.

On the plus side the speakers are above average, and there's plenty to configure in the OSD including overdrive, low-latency and low blue light modes. Perhaps most unique of all are ambient LEDs that reflect light below the monitor for 'mood' lighting. We found it a bit gimmicky, but there it is.

Verdict

If not for the problems we encountered, it might have been a must-buy.

★★★★☆
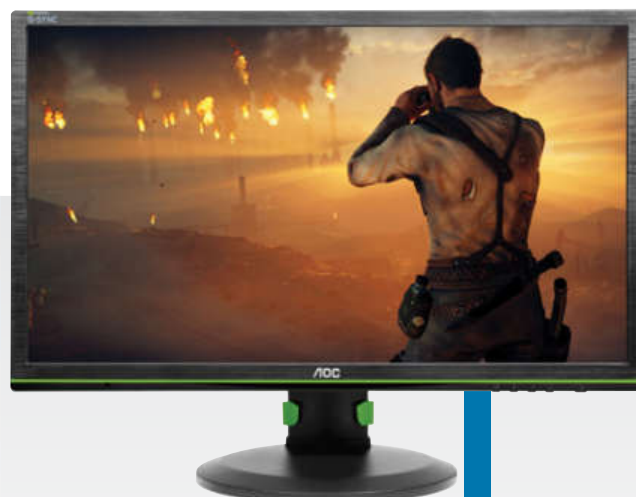
AOC G2460PG

G-Sync powered version of its 24-inch brother.

Another example of the price difference G-Sync makes, as the G2460PG and G2460PQU offer roughly the same display but with FreeSync and G-Sync respectively, and coming in at $200 more expensive.

And the higher price actually gets you less — gone are the varied ports of the G2460PQU leaving you with just one DisplayPort. The OSD is also a different beast and delivers less features. Of the options in the G2460PQU the only ones that remain are the overdriving and the Break Timer. It has however one extra — ULMB for Ultra Low Motion Blur, though this can't be enabled at the same time as G-Sync.

Like the G2460PQU the base is sturdy and solid and offers tilt, rotation and height adjustments along with portrait mode support. The chassis is underlined, no surprise, by a green line for Team Green. Controls can be found along the bottom, with one these enabling a crosshair that's superimposed on the screen as with the ASUS models.

In testing the panel lived up to the 144Hz ideal and provided smooth gameplay, though the level of contrast didn't quite match its 24-inch brother, perhaps as a result of the more varied image controls on the G2460PQU.

The extra cost of the G-Sync module, for which Nvidia is charging a premium, is a barrier to entry for its use. If you have the GPU power to pump 144fps in your games, you might as well save $200 and get the G2460PQU with more features, or save $100 and go for the 27-inch G2770PF.

Verdict

Not quite as polished as the G2460PQU, and at a higher price point too.

★★★☆☆

AOC G2460PQU

Fast and feature rich with this 24-inch speed star.

As one of two AOC 24-inch monitors in our test, and with this one being the FreeSync model, it's no surprise that the chassis is underlined with a red bevel to indicate Team Red. It didn't deliver the best first impression, as our sample had a dead pixel near the centre of the screen.

Despite the fact the monitors are very similar in design, there are some key differences. The connectivity is much more on the G2460PQU with DSUB, DVI, HDMI and DP and the OSD looks different and has different options. Here it mirrors much of the 27-inch G2770PF functionality and includes AOC features such as iCare, which adapts brightness in response to ambient light; DPS, aka the dynamic power saver and alters contrast; DCR, your classic dynamic contrast; and DCB, which features settings such as 'Nature Skin' and 'Green Field' and which isn't explained in the manual, and in testing the results depend on what you're viewing. It also features 'Bright Frame' and the 'Break Reminder', which we like.

The TN-panel viewing experience is quite good, amiable contrast and colours, though the whites drown out nearby hues depending on what setting you're using, with 'Standard' being the worst. Some tweaking in the settings fixed this though.

If you don't need G-Sync this is the better monitor of the two AOC 24-inch models, and if you can afford $100 more you might as well go for the AOC 27-inch G2770PF and get most of the same features but with a bigger screen to boot.

Verdict

Good all-rounder with lots of features for those on a budget.

★★★½☆
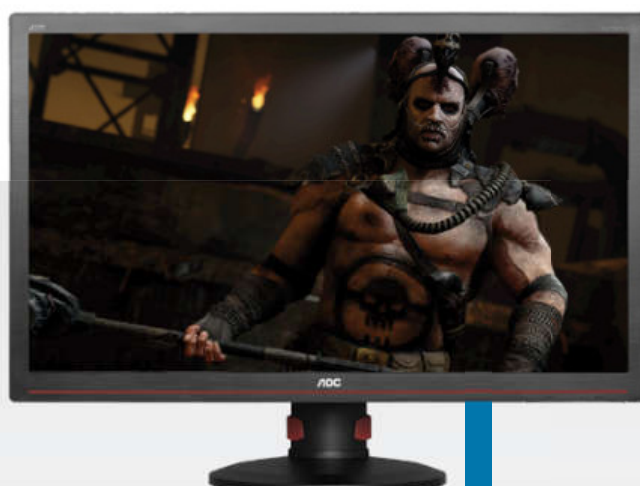
AOC G2770PF

27-inch form factor with FreeSync at a decent price.

AOC is well-known for making decent mid-range monitors that won't break the bank, as evidenced by this 27-inch 1080p display for $499. On top of this it sports FreeSync and can clock it right up to 144Hz, which is a joy to behold. As far as TN-based panels go the quality isn't as impressive as say the BenQ or Samsung TN-displays, seeming to be more washed out than its compatriots, even after playing with contrast, brightness, and the various colour modes. But again, those monitors cost almost twice as much.

Similarly the OSD is nothing to write home about but includes all the essential options, as well as adding a configurable overdrive to reduce ghosting even further, along with a Dynamic Contrast Mode (though we found it better to leave it disabled), and 'Bright Frame' which lets you create a set area on the screen with a different brightness level. One nice touch we thought particularly relevant to a gaming monitor was the 'Break Reminder', reminding to you — well — take a breather every now and then and stretch your legs.

The chassis is chunky and the bezel large, but features the necessary tilt and height adjustments, including being able to operate in portrait mode. One point in its favour is a wide range of ports, including the old analog DSUB VGA. It also features built-in speakers for the price, but don't expect miracles.

If you're budget limited but set on a 27-inch, the AOC G2770PF is certainly worth consideration.

Verdict

One of the cheaper 27-inch monitors you will find, and with 144Hz to boot.

★★★½☆

$899 | WWW.ASUS.COM/AU

$1,049 | WWW.ASUS.COM/AU

ASUS MG279Q

High-speed, high-res, and IPS — what's not to love?

ASUS is striving for the holy grail in the MG279Q, and it certainly comes close. Whereas many IPS monitors top out at 75Hz, the latest in ASUS' gaming-centric line delivers 144Hz, IPS, at 2,560 x 1,440 and with 4ms response time. Glorious.

And it's decent looking too, with thin bezels and a solid base that provides tilt, height, swivel and rotation as well as portrait mode. The attention to detail flows into the OSD, where there are plenty of tweakables including 'special' gaming modes ranging from Racing to FPS. Some of these modes use ASUS' 'Vivid Pixel' feature, which is essentially an over-blown sharpening filter that on high levels is an affront to the eyes.

The OSD is controlled via buttons on the right rear and a navigation joystick. This is the best of both worlds, providing quick access to functions and easy menu navigation. Other gaming-centric features include crosshairs for FPSs and, interestingly, a countdown timer. Added to this is a Blue Light Filter mode to help reduce eye strain, and TraceFree overdriving to reduce ghosting and blur.

Playing games on this is simply a joy, but note enabling FreeSync limits the monitor to 90Hz. This isn't necessarily a bad thing, it's still a 50% improvement over your standard 60Hz IPS, and provides silky smooth gameplay if you fall below this. It's seriously hard to go back to anything else once you've used IPS at 1440p at 90 or 144fps, so here's hoping we'll see more models hitting the market to give ASUS some competition.

Verdict

Has all bases covered, hard to beat. Now if we can just get this in a 30-inch model...

★★★★★

ASUS PG278Q

Speed and style combine with G-Sync.

Comparing the PG278Q to the MG279Q is a good exercise, as it demonstrates the difference G-Sync makes to pricing. The PG278Q is around $150 more expensive than its brother, and yet utilises an inferior TN panel compared to the MG279Q's IPS. Apart from this the specs are much the same, sporting a 2,560 x 1,440 resolution and up to 144Hz performance. The one advantage the TN panel has, and this is the case across the board with TN versus IPS, is a slightly faster response time — but in our experience testing these monitors you'd be hard pressed to notice.

To be fair the PG278Q is an older design, and while we saw tell-tale TN issues like colour fading in the corners and a more washed out contrast, it was none-the-less blissful to game on it at 144Hz. It also sports ASUS solid design with a sturdy base and thin bezels, as well as much the same gaming oriented features as its newer cousin — the 'crosshair' and 'timer' options, ultra-low motion blur, and a 'Turbo' button to switch between 60, 120, and 144Hz on the fly without using a driver control panel.

The PG278Q holds its own but at the price it's easy to argue there are better choices. However if G-Sync is your requirement, then this limits your choices somewhat. Note that an IPS version of this monitor called the PG279Q, essentially the MG278Q but with G-Sync, is due by the end of the year.

Verdict

A top contender let down by the G-Sync price premium.

★★★★☆

HOT PRODUCT

$829 | GAMING.BENQ.COM

$269 | WWW.KOGAN.COM.AU

BenQ XL2730Z

Form and function combine with BenQ's impressive FreeSync display.

BenQ's 'reddot' design award winning monitor is one of the better looking panels in our round-up. The bezel is relatively thick but complimented by a sleek stand that incorporates a well positioned carry handle and measurement markings for tilt, swivel and height adjustment. A great idea to help you restore your ideal preferences if it's moved.

Featuring 2,560 x 1,440 pixels it has excellent sharpness and detail in games, and combined with the 144Hz maximum refresh rate was a pleasure to play on. The OSD is simple and functional and provides quite a range of tweakbles that include standard picture settings as well as a Black eQualizer function to brighten shadows without over-exposing lit areas and Motion Blur Reduction to further reduce ghosting. A selection of gaming presets include FPS and RTS as well as your own settings.

The customised presets tie into another unique feature: an external controller. This round device can sit in its slot on the monitor or move around via its (not too long) cable. This allows you to change presets and navigate the OSD without using the monitor buttons.

Finally one particularly nifty inclusion — which we now wish all monitors would have — is a spring-loaded hook that comes out of the side to let you hang up your headphones. Great!

If it were IPS the XL2730Z would be the 27-inch monitor to have, that said the use of a TN panel provides slightly faster response times and a cheaper price.

Verdict

The XL2730Z almost has it all, add it to your list.

★★★★½

Kogan KALED24144A

Kogan delivers 144Hz at an unbeatable price.

Kogan has made a name for itself by pushing price boundaries, and its foray into gaming monitors is no different. It's cliché to say no frills but this is what the KALED24144A presents. The stand is a simple base, and the chassis is glossy plastic with thick bezels.

However the panel itself is good, in fact as far as TN goes it had commendable contrast and bright colours without much of the washed-out look that some TN panels suffer from. And while there's no FreeSync or G-Sync option, it delivers on the 144Hz promise and gaming on the display is slick and fast. It had a notable softness in motion that other TN panels we looked at here didn't have, however, likely an effect of a slightly slower average response time.

The OSD is controlled via rear buttons and doesn't offer many options beyond contrast, brightness and colour controls. The most notable features are a dynamic contrast mode called DCR, which has some effect but tended to lose details in the image, and a range of settings which compromise viewing preferences in the form of Standard, Game, Movie and Text.

It also sports a 'Low Blu Ray' feature that, like other monitors we covered here, aims to reduce eye strain by reducing blue in the background LEDs. It has four setting levels and actually works quite well. A small issue is the screen coating, which very slightly mottles the view, visible mostly with white backgrounds.

But look at that price — by far the cheapest 144Hz display you can buy.

Verdict

You get what you pay for, but with the KALED24144A it goes a long way.

★★★☆☆

$849 | WWW.LG.COM/AU

LG 34UM67

Wide-screen gaming bliss with IPS and FreeSync.

The LG 34UM67 is an interesting mix of class and less-than-stellar design. A large 34-inch 2,560 x 1,080 IPS display gives gorgeous visuals ensconced in a thin bezel and clean exterior. Beautiful. However this is marred by a fixed stand meaning no tilt, swivel or height adjustment, the most unforgivable of these being the latter — to get the display at an ergonomic level you'll be propping it up on books and boxes. For the money we'd hoped for a little more.

A welcome feature is the control for the OSD, which is a small directional joystick underneath the display. This is easier on the arm and fingers to navigate than the traditional multi-button on the sides or front.

While the display maxes out at 75Hz, it does support FreeSync to ensure smooth gameplay if you drop below this. Other gaming features include a 'Black Stabiliser', which essentially brightens dark areas but can also wash out an image; 'Dynamic Action Sync', which is fancy marketing speak for a low-input delay (and indeed it is); and 'Game Mode' profiles such as FPS and RTS, though with these your mileage may vary.

As an IPS monitor with a price close to the ASUS MG279Q, it's an interesting toss-up — the LG 34UM67 is larger with its 21:9, 34-inch size, and this is definitely a boon in games. The ASUS MG279Q is only a 16:9, 27-inch model by comparison, but has a higher resolution and cranks it up to 144Hz, which is hard to beat. Ideally you'd want try and can get in front of both to decide.

Verdict

A more affordable 34-inch display, let down by its fixed stand.

★★★★☆

$849 | WWW.SAMSUNG.COM/AU

Samsung U28E850R

4K grandeur with FreeSync, packed into a 28-inch display.

Samsung doesn't do things by halves and its U28E850R packs 4K of pixels into a 28-inch screen. HDMI 2.0 or DisplayPort is required to power this, not to mention a beefy GPU or two when it comes to games. As far TN-panel displays go it's one of the better ones with good contrast and vibrant colours that don't look as washed out as TN-panels tend to be.

The OSD allows you to split the display into two with Picture-in-Picture mode utilising two different inputs, and an interesting Samsung 'MagicAngle' feature sports presets such as 'Lean Back' and 'Standing' that attempt to compensate for a TN-panel's less than stellar viewing angles. Does it work? Kinda, the results are more a matter of taste.

Another neat feature is 'Eye Saver' mode which can be toggled with a single-push and will reduce blue light and contrast whilst dimming the screen. It works well once your eyes adjust, and a great option for working at night.

For gaming a 'Gaming Mode' claims to optimise the display for gaming, though we found it tended to over-sharpen the image. Overdriving is also configurable, though on the 'Fastest' setting we saw some artifacts in motion. While not included, an optional soundbar can be mounted onto the rear.

The U28E850R is exemplary of Samsung quality but for the price you can get the ASUS MG279Q with 2,560 x 1,440 res and IPS, or go large with the LG 34UM67. The charm here is 4K, as long as you have the grunt to power it.

Verdict

This in IPS would be an easier sell, but otherwise it ticks all the boxes.

★★★★☆

Gearing up for 144Hz

Everything you need to know about setting up your system for high-framerate gaming.

Gaming at 144fps is a whole new experience, but 144fps is more than double what most PCs are used to powering. So here, we've put together a set of guidelines to help ensure you reach that sublime, smooth gaming experience.

WHAT YOU NEED

Before you dive into 144Hz, it's worth checking what you need to get the most out of it.

- By definition powering a faster update rate, or a higher resolution, requires more bandwidth. And if you're increasing both, such as 144Hz on a 2,560 x 1,440 display, then you need even more.
- For 1,920 x 1,080 at 144Hz you need a GPU with at least HDMI 1.3 or above. Dual-link DVI will also work, as will DisplayPort 1.1.
- For 2,560 x 1,440 at 144Hz you'll need a GPU utilising HDMI 2.0 or DisplayPort 1.2.
- Generally, DisplayPort is the better choice if you have it, but either can be used going up as far as 4K. Here HDMI 2.0 tops out at 60Hz, and while DisplayPort 1.2 has 50% more bandwidth, it's not enough to run a 4K display at 120Hz. That will require DisplayPort 1.3, which no GPUs or monitors currently support.
- Which leads us to the second consideration — playing 144Hz needs more GPU grunt to maintain 144fps consistently. If your current GPU struggles to maintain 60fps at 1080p, you're going to want to upgrade. Your mileage may vary depending on the game engine — the latest AAA blockbusters tend to really push the envelope — but once you start aiming for 144Hz at higher resolutions like 1440p, SLI or Crossfire is all but a must.

DisplayPort is required for 144Hz gaming at high resolutions.

- Finally note that if you're opting to use G-Sync or FreeSync, DisplayPort is required.

Now assuming you have enough GPU power, what else can you do to make the most of 144Hz?

GPU AND CPU

It goes without saying that you can often squeeze a decent performance jump out of overclocking your GPU(s). Indeed, it's so ingrained a practice that most manufacturers release pre-overclocked GPUs. Even if you have one of these you can often push it a little further — just keep an eye on temperatures and test it thoroughly with benchmarks like Furmark (**www.ozone3d.net/benchmarks/fur**) to see if it's stable.

But there are two sides to the framerate coin — depending on the game, the bottleneck for your fps may be the GPU, or the CPU. Once there's enough GPU power to drive your display at 144Hz, you still need a fast enough CPU to feed it. Hence, overclocking your CPU is just as important as overclocking the GPU when it comes to maintaining high frame rates.

One reason for this, and something that up-coming DirectX 12 games may mitigate a little, is that DirectX 11 and lower games all funnel draw calls through a single thread. This means single-thread performance is paramount on a CPU for feeding the GPU, and the reason why high CPU overclocks increase in-game framerates where the GPU is waiting

Windows 10

Windows 10 is still wet behind the ears, and driver iterations can make a big difference at this time. If you're using Windows 10, it's wise keep up to date with the latest GPU drivers for your card.

Also Microsoft's new Game Bar (Windows key-G) overlay, which allows you to record gaming sessions, is automatically enabled and can negatively impact on frame times, even if you don't use it. Turn if off by loading the XBox app, going to Settings, then Game DVR and disable it.
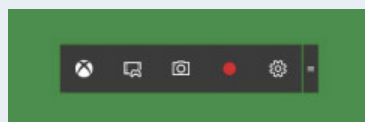
Windows 10 introduced the new Game Bar to allow recording in-game.

on the CPU.

DirectX 12 distributes the rendering load across multiple cores, so as we see Direct 12 titles arriving you'll have a greater opportunity to reach 144fps with these titles. Assuming, of course, their next-gen engines don't crush your GPU underfoot as they dazzle you with the latest graphical innovations.

CONFIGURING THE MONITOR

For the monitor itself there are a few settings you can play with —

Overclocking can help gain a few more fps to maintain a high framerate.

overdriving or ULMB (ultra low motion blur) can reduce ghosting even further and help at high framerates, just note the implementation depends on the type of display and the manufacturer. Also, overdriving and ULMB may be incompatible with FreeSync and G-Sync respectively.

In fact, as FreeSync and G-Sync are both designed to help mitigate the effects of falling below your monitor's maximum refresh, if you can consistently maintain 120fps or 144fps, it's actually better to utilise the overdrive and ULMB modes at these rates and leave FreeSync and G-Sync disabled.

However, enabling them can also be of benefit if you Vsync lock at the upper-end of their range — depending on the implementation, FreeSync or G-Sync may operate within a refresh rate boundary different from the monitor's maximum. For example, FreeSync operating at up to 90Hz. In this case locking at 90fps will give you a smoother experience with FreeSync than at 144Hz if your GPU can't keep up.

Indeed, if your monitor supports other refresh rates it can also be helpful to limit yourself to one of these as well, for example most 144Hz monitors will also let you choose 120Hz. The difference between 120 and 144 is small, and yet will allow you to reduce the load your GPUs need to work on in order to deliver a smooth experience.

IN-GAME SETTINGS

If you've got your hardware overclocked, and your monitor all setup, but your rig is just falling short of maintaining a consistent fps in a particular game, what else can you do?

Firstly, ensure it's loading from an SSD. Most games these days, especially open-world ones, utilise real-time streaming to manage the demanding task of immersing you in a seamless world. It doesn't matter how beefy your GPU and CPU are, the game is going to stutter if it's waiting for data to load in from your drive.

Next dial-down the AA. The higher the resolution you run at, the more demanding each level of multi-sampling anti-aliasing becomes. Alternatively, choose a shader based AA like FXAA or SMAA if the game supports it. If it doesn't, inject it yourself with a tool like Reshade (**reshade.me**).

Then of course you can play with other detail settings, such as view distance which can also really help, to net you those extra frames and help you stay close to 120 or 144fps. ■
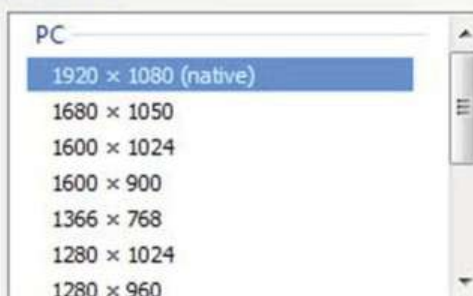

G-Sync and FreeSync aren't necessary to enjoy 144Hz, but can help.

Setting the monitor to 120Hz will let you achieve seamless gameplay but with reduced load on your GPU.
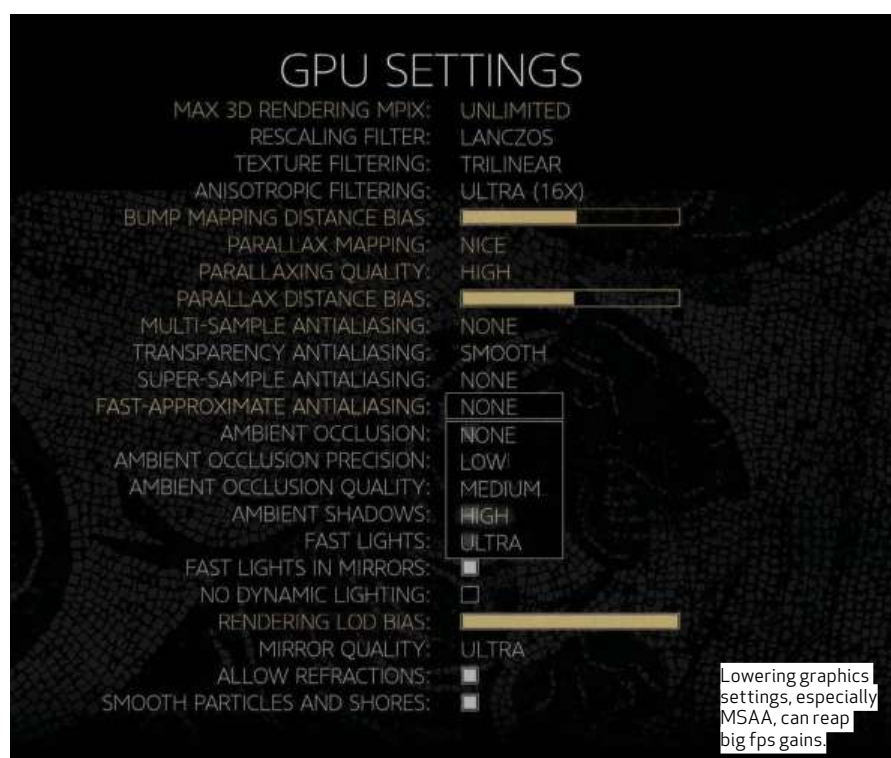
Lowering graphics settings, especially MSAA, can reap big fps gains.

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No Man's Sky will procedurally generate billions of worlds, ships and creatures.

EMBRACING THE RANDOM

**HOW GAMES HAVE LEARNED FROM ART, MUSIC AND MATHS
— AND HOW THE WORLD MIGHT LEARN FROM GAMES.
DANIEL GRILIOPOULOS**

And on the third day, God made the world. And He saw that it was rubbish. And He then looked at the other worlds that He'd made, and thought, "They're a bit naff, too, infallible as I am."

So He pondered for silent indefinites, as the void drifted tetchily on, waiting for time, space, gravity, bicycles and all the other concomitants of virtue and vice. Eventually, He got a bit frustrated. "Bollocks to it all," He thought, blasphemously. "Handcrafting a universe is for losers. I'll procedurally generate an infinity of them and just choose the best one." And lo, that was the morning of the third day, and He saw that it was good.

As a child, I remember being fascinated by Mandelbrot. I didn't at that time know what the word meant, except that in the corner of our IT room at school was a single, fast Acorn computer that the IT teacher treasured and guarded. The only thing he seemed to run on it was a Mandelbrot simulation, which we used to sit and watch over our lunch break. It would take ages to draw each screen as it zoomed in on part of the structure, which would always reveal more structure and more complexity. Eventually, sometimes, it would repeat.

A Mandelbrot drawing is a representation of a mathematical set — the set of complex numbers that do not tend to infinity; which is to say, equations involving imaginary numbers; which is to say, numbers that involve the square root of -1. Which is to say… that I didn't take maths past HSC level and this is really difficult to understand. So I promise there won't be any more equations in this article.

More interestingly for our purposes is that, whatever else Mandelbrot is, it's an equation that throws up astounding complexity and beauty without the user having to create anything themselves. Look closely and you can see it features spirals, valleys, seahorses, tentacles, antennae, double-hooks, islands. The mind's eye sees cityscapes, ships, people holding hands, trees and organic structures that have never existed. And all this is created from an equation?

Well, only with a computer. Fractal art, like Mandelbrot, mostly exists as an outgrowth of using iterative methods to solve polynomial equations, and that really requires a computer. Looking at generative pieces, it's hard not to agree that they're art — but the artist has at most set the parameters for their creation, not hand-crafted the piece, or in this case, hand-solved the maths.

Similarly, 'generative music' can be constructed without direct user input. One could also argue that Bach's fugues were generative, given that they were based on a strict underlying mathematical process out of the control of the creator. There's even generative writing, which has grown from the 'cut-up' techniques of writers such as William Burroughs or Georges Perec, and France's mechanical-writing Oulipo school.

That's the heart of procedural generation. It's grown out of maths, through art and music, and it's taking over gaming. Where will it stop?

"People have always been fascinated with creating unpredictable things by following rules," explains Michael Cook, an academic who specialises in procedural game design. "Even children's games where you pass along bits of folded paper and each write part of a story. It's all about being delighted at something strange coming from nowhere in particular.

"We've dreamed of machines that make things for a very long time — Ada Lovelace wondered about machines that could write music long before Alan Turing was even born. I think there's just something magical about the idea of something coming from nothing — and I still feel that magic each time I work on a new generator!"
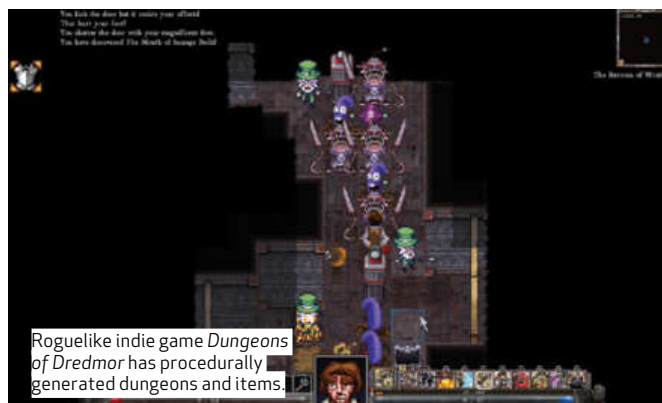
A ROGUE'S HEART

Cook's main project, Angelina, is a special case, which we'll talk about later. But he's right about our love of the emergent outgrowth of rule structures. "Of course, there's nothing better at following rules than a computer, so it didn't take long for programmers to give computers recipes for generating complex, beautiful things. Computers let us transform theoretical patterns and ideas like fractals and L-systems into amazing machines with moving parts that could be poked and examined and executed again and again."

The most standard usage of procedural techniques in modern gaming is in roguelikes and indie games, such as *Minecraft, Dwarf Fortress* and *NetHack*. It's an area that Nicholas Vining's Gaslamp Games specialises in, and he's adamant that it's essential for certain genres.

"For the games we make," says Vining, "you have to have procedural generation. Both *Clockwork Empires* (a steampunk colony builder with a Lovecraftian twist) and *Dungeons of Dredmor* rely on having a lot of replayability. and a good way to get replayability is to have it change every time. You really want to have random geography and random levels and random stuff being thrown at you."

Roguelike indie game *Dungeons of Dredmor* has procedurally generated dungeons and items.

The Mandelbrot set produces infinite complexity from a simple formula, and many of its results look like abstract art.

But why use procedural generation? Surely we've got by perfectly well handcrafting them so far? "People want giant experiences, and value for money," says Vining. "AAA games deal with this by giving them 100 hours of hand-massaged content — *Dragon Age: Inquisition* is the most recent example — but that doesn't scale unless you're making, you know, *Dragon Age*. (And then you'll end up probably having to make money by DLC.) Being indies, we have to cheat. And frankly, hand-massaging 100 hours of content is more laborious than it needs to be."

ON THE TUBE

Vining is also keen to make the game easy to share and non-repetitive — not merely for the end user, but to attract the YouTubers who mostly drive a game's fame today.

"We're now making games for players who want to also show themselves playing the game, on YouTube, and doing stuff. I think you're stuck with that nowadays. I think *Minecraft* did it to us. So, you have to make a game where YouTuber X playing the game can have a completely different experience than YouTuber Y.

"If you look at the stuff that gets put up on large YouTube Channels, it's things with a creative element, a procedural element, and also *Goat Simulator*. Procedural content gives you just enough hooks upon which a good storyteller can hang their own hat. I think that's something that *Minecraft* either got or stumbled upon — there's a certain level of crudity needed where you can then have a child just stick their imagination on it, and have something wonderful happen, and a lot of the people gunning in the same space have never really figured that one out. "

LIMINAL PROCEEDINGS

By contrast, Dr Tom Betts's motivations are less about speed or fame, and more about interesting outcomes. Dr Betts started as an arts student at Goldsmiths College in London. "I was really interested in the idea of creating systems that would make art work for me. I'd always been into computers and games so it made sense to combine those interests. I taught myself to program and I've been making generative and proc-gen software ever since." Dr Betts has created art, performed music and has been the lead programmer at indie games company Big Robot since 2008.

"I find it interesting that working with proc-gen is always a sort of collaboration between the programmer, the program code and the player. You can't dictate the outcome as precisely as you can in traditional production methods, and that makes it more interesting. Also, in terms of art and music, generative/proc-gen work has its own sort of aesthetic that comes from its ability to produce large numbers of variations on a theme, all of which are different, but maintain a shared style."

Several of Dr Betts's games have involved procedural generation. *Sir, Are You Being Hunted*, for example, uses a procedural system to generate all the terrain, housing, flora and fauna in its open world. "Procedural generation can aid the creation of all kinds of game world, especially in the case of large open-world games or anything with roguelike aspects. It can help smaller teams build larger environments and it can automate or assist many of the processes involved in larger studio production pipelines. We will undoubtedly see the usage of PCG tools and methods grow as games increase in complexity and production cost."

INNER EXPLORATION

Cook has yet another motivation to use
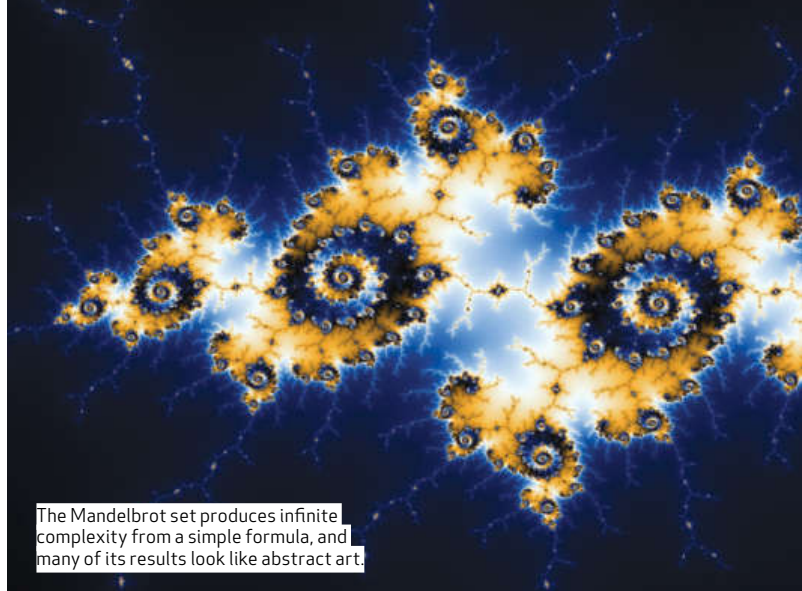
Generating Escapism

Procedural game design academic Michael Cook said something very interesting. "Depending on how VR designers want to take the tech, procedural generation could be the defining technology of the VR age." As we've explored in previous months, AR and VR are taking the lessons from games and growing them into whole new fields — Oculus is even employing ex-Pixar staff to make VR kids movies.

Of course, like AAA games, VR has to be convincing to work, and the hardware can't do it alone. It needs tons of convincing content — a lot more than any game, because it has to be all around the player and in great detail. Procedural generation might not just be helpful in creating these worlds and objects, it seems essential.

Valve and HTC's Vive system adds even more complexity, given that it uses extra cameras to map the dimensions of the room. That means shifting the size and shape of the rooms you're experiencing through the device, which means the designers will have to create the game with variable locations for cues and objects. Your fantasy tavern might just be a few feet across and need a keg in the middle to hide your coffee table, or it might be very big and absolutely clear.

Cook has ideas on how this will be dealt with. "The way we'll solve these problems, I believe, is by having procedural generation systems that are intelligent enough to redesign games to fit inside your room. So the game designer specifies what needs to be in this tavern — a bar, a table, a door — and then your HTC Vive automatically detects where these things should go.

"It generates the layout of the room to make sure you don't walk into that expensive vase you have in the corner, or accidentally put your knee through the TV. To me, VR is an amazing new environment to do procedural generation in."

procedural generation — the reintroduction of genuine exploration to games. "*Minecraft* showed an entire generation of gamers how procedurally generated worlds could inspire a sense of discovery, exploration and awe — there are similar revolutions around the corner for generated game mechanics, generated stories, and so on. It's incredibly exciting." Part of that is there can be no walkthrough to a proc-gen world — at most, some recipes and best practice recommendations.

Cook is also interested in the development of aids to game development, which also come under the heading of procedural generation. "There's a lot of interest in building software that can help people design games, either by learning how humans design, or using a big database of rules. For example, imagine feeding every *Team Fortress 2* level into a machine-learning system, and then using that system to evaluate, comment on and even adjust levels designed by modders.

"The other big thrust is the automation of new areas of game design, moving out of the same old areas like dungeons and levels and looking into generating other, harder kinds of content. I'm really excited by this move — there are genres out there that we can't imagine right now because we're waiting for new generators to come along and show us the way. Last month at a conference I saw systems which can generate metaphors, cocktails, dancers, fables and jokes. I'd love to see all of these things built into games, games that can generate new kinds of content beyond trees and rocks. I want games to write theme songs for my MMO character. I want games to write myths

kkrieger used procedural generation to shrink the game to just 96kb.
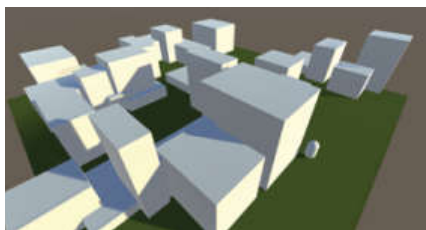
Angelina generates entire games — though they can look quite plain.

about my epic journey. I want games to procedurally generate me a best friend I can talk to. I want to see new things coming out of our computers."

BRIDGE OF SIZE

Vinings agrees, particularly when it comes to music. "Repetitive music drives me nuts; once you've listened to *Dungeons of Dredmor's* entire soundtrack, good as it is, you've heard it all. We tried to modulate this in *Clockwork Empires* by having the soundtracks adjust themselves as your mood changed, and while it does work pretty well, it doesn't work as well as it could if we iterated on the technology for a few more rounds.

"The problem is that you have to have somebody who is a musician and a programmer, and you have to build tools. It's a very complex process that requires specific sorts of individuals. How do you teach a computer about orchestration?" Despite that, we have taught computers about things like image recognition (see "Dream of the Deep", right).

One of the most interesting procedural generation benefits has to do with file size. Today we're growing accustomed to an endless increase in our computer's storage capacity — 1TB drives are now commonplace. But in areas of constraint, procedural generation can massively reduce file sizes, or eliminate the need for in-game assets completely.

When Naked Sky Entertainment's game *RoboBlitz* launched on PC and Xbox 360 in 2006, Microsoft had decided that the largest downloadable game it would allow on the system was a

Dreams of the deep

There are ways other than procedural generation and handcrafting to generate content. The most spectacular in recent weeks has been the frankly terrifying and hallucinatory images coming out of the Google Deep Dream project.

This project works by starting with a neural network. These are typically piles of 10–30 stacked layers of artificial neurons. The team starts training the neural network, using millions of examples, and then adjusts the network parameters gradually over time so that fidelity isn't lost, but random noise is.

Each layer of the network extracts higher level features than the previous one, until the final layer decides what the image looks like. So, the first level might detect edges, then intermediate layers might detect recognisable shapes, while the final layers assemble them into complete interpretations. This is exactly how Google Photo works, too.

The reason these horror pictures have been going around, of people with hundreds of dog's eyes making up their face, is that this particular neural network, called Deep Dream, has been fed data from ImageNet, a database of 14 million human-labelled images. But Google only uses a small sample of the database, which contained "fine-grained classification on 120 dog sub-classes".

It's the opposite of Mandelbrot's images. Instead of seeing the same pattern as we go deeper into the image, the computer sees the same pattern everywhere it looks. Sadly, the pattern happens to be that of a dog.

Pizza Hut's Four 'N' Twenty Stuffed Crust pizza gets the Google Deep Dream treatment. Yes, we're also scarred from this. We're off to scratch our eyes out.

SpeedTree can generate believable trees and foliage using mathematical formulae. It's been used in *The Witcher 3, Shadow of Mordor* and *Far Cry 4*, among many others.

tiny 50MB, to fit on one of their (tiny for the time) memory sticks. Yet *RoboBlitz* was the first game to run the then-revolutionary Unreal 3 engine. As Naked Sky's chief technical officer Joshua Glazer told us, they used lots of tricks to get the game down to under 50MB — among them procedural generation.

"All those levels would have loaded a lot faster if it weren't for Microsoft's 50MB requirement, coupled with the requirement that we couldn't have any kind of 'install' process that unpacked the game after download," says Glazer. "We procedurally generated the textures for everything except Blitz (the hero) and the baddies. Pretty much every single square inch of the levels and most of the props were procedurally textured using Allegorithmic's cool procedural texture-gen tools. Also, all the animation was procedurally driven by physics. We also procedurally modified our sound effects on the fly so that we could get more use out of the samples we were able to squish in the package. The levels were not procedurally generated — we didn't experiment with that until our 2010 game, *Microbot*."

Naked Sky's latest game, *Scrapforce*, has mostly avoided procedural generation, save for an interesting-sounding stochastic AI system. And *RoboBlitz* isn't the smallest game made using procedural techniques — that prize almost certainly goes to .kkrieger, a 2004 first-person shooter that's only 96KB in size — but it is the most impressive for its size.

HARD LIMITATIONS

Despite all these positives, there are limits to procedural generation. Firstly, it can be processor intensive. *Dwarf Fortress* can take several minutes to get a game going, despite only displaying its graphics in ASCII. Gamers who are used to the rapid loading of mobile games might find this frustrating. And it's power-hungry too, as Cook explains.

Clockwork Empires aims to become a more accessible *Dwarf Fortress*.

"If you're generating things like stories, or special abilities for an RPG, you want to know that they make sense, that they're balanced, that they're fun. That's an extremely difficult thing to test, and it often needs a lot of playtesting — and that means more computing power."

Another problem is that procedural generation works best in clearly delineated areas. Because it's so hard to define things like 'beauty' or 'fun', procedural generation often stays in areas where it knows it can perform. In those areas, it's commonplace. "Procedural art systems for trees and rocks are really popular — you probably don't even notice the games they're used in half the time," says Cook. "People don't really notice if a branch is slightly out of place, and trees follow quite clear natural rules that we can give to a

Minecraft's genius is in combining a procedural world with user customisation.

computer, so it's a perfect use-case." For example, SpeedTree, the games industry standard tree generator, has appeared in nearly every AAA game for the last few years.

Cook explains that when using "generative software in music, art or films, we mostly use it to target things where imperfections are hard to see (abstract art instead of portraiture), things that aren't the focus of attention (crowd scenes instead of big centrepieces), and preferably things where there are clear patterns and rules (I think electronic music benefits here)." Games, however, often allow procedural content to be closely scrutinised, increasing the quality threshold hugely.

The game combining all these elements is *Dwarf Fortress*, currently the high point of procedurally generated games. "One of the strengths of *Dwarf Fortress* — a huge inspiration for *Clockwork Empires* — was that everything is procedurally generated," says Vining. "History, terrain, monsters, gods. The newer stuff in the upcoming *Dwarf Fortress* patch, with procedurally generated libraries full of procedurally generated books and poetic forms, is completely insane in the best way possible."

Proc-gen media

Fiction book: Life, A User's Manual

Written by Georges Perec, in line with the Oulipo manifesto, this book isn't strictly speaking programmatic, but Perec wrote it in line with formulaic constraints that meant he had to write about a certain room, in a certain building, with certain people and objects » interacting in every chapter. Perhaps because of that, it comes across as a weird jigsaw puzzle of a book. And somewhat long-winded.

Fact book: Philip M Parker

Professor Philip M Parker has patented a method that automatically produces books from a set template, which is then filled with data from internet searches. He claims to have produced over 200,000 books, ranging from medical science to dictionaries about just one word, with most of them being print-on-demand only… he's also started generating factual books for under-served languages, in collaboration with the Bill & Melinda Gates Foundation.

Music: Brian Eno

Back in 1996, Brian Eno used Intermorphic's SSEYO Koan software to create his album *Generative Music 1*, which was in fact a piece of software itself. The music ran off a floppy disk and 'improvised' within the 150 parameters that Eno had set to create a different track every time. He's continued to experiment throughout his life.

This is not a photo, but an example of how real SpeedTree's tech can look.

THE APEX

Developed by two brothers, Tarn and Zach Adams, *Dwarf Fortress* procedurally generates almost everything you could imagine. According to Tarn, in their previous game, *Slaves to Armok*, "you could zoom in on your character, and it'd tell you how curly his leg hairs were, and the melting and flash points of various materials. It was insane." *Dwarf Fortress* goes further.

The entire world and its history is generated, epoch by epoch, before you start playing, with kingdoms rising, dark gods falling, and magical items being lost for centuries. Then it generates the landscape and terrain you're in, the dwarves you're nominally in command of, the local flora and fauna, and a hundred other things, including art and poetry that references in-game events. *Dwarf Fortress* is so impressive and rigorous, but also insane, that people have built working computers inside it. That's right, a virtual machine running inside a game.

Michael Cook's Angelina simulation can't claim to be as complex as *Dwarf Fortress*, but it's increasing comprehensiveness in a different direction.

That's because Angelina (**www.gamesbyangelina.org**) is an experiment in computers designing and evaluating video games autonomously. "The games Angelina produces aren't procedural," he explains. "All the generation happens during the design of the game, but Angelina releases static games like you or I might if we made a game. It's all about how we can procedurally generate a game design, ideas, art, mechanics, music and put it all together, rather than generating what happens in the player's computer when they're playing."
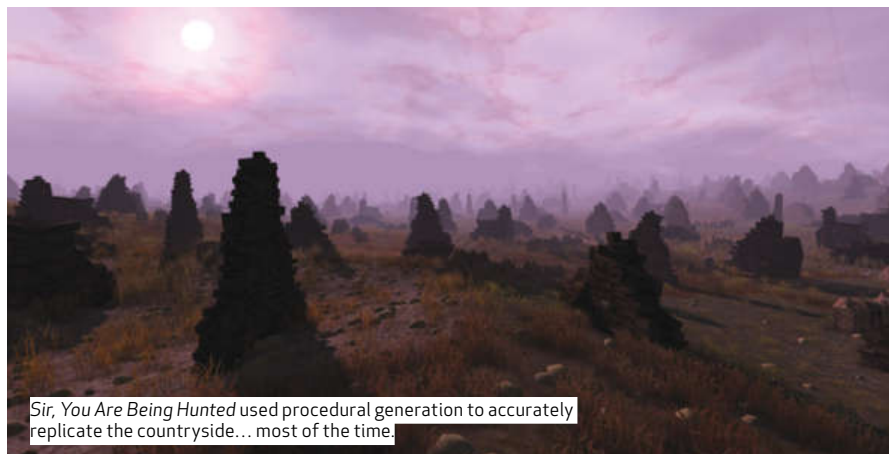
Sir, You Are Being Hunted used procedural generation to accurately replicate the countryside… most of the time.

ANGEL WITH A BROKEN WING

"Angelina is interested in generating everything in a game, which means we have to tackle the hardest problems for procedural generation, like aesthetics and emotions, as well as the more rule-based stuff like generating mazes and rocks. I want Angelina to generate program code, and game mechanics, and systems of meaning so it can tell you a story with its games or make you think."

These two types of comprehensiveness — *Dwarf Fortress's* obsessive inclusiveness and Angelina's procedural game design — are core to the story here. Games, and their successor, VR (see "Generating Escapism, page 64), are a universal experience. They can contain everything else in the world, so they take in every other part of generative art, if everything's not to be handcrafted at great expense.

The only way to do that, without us all becoming developers, is procedural generation. ■

Film: WETA and Massive

The huge armies in the conversion of Tolkien's trilogy were generated by a collaboration between WETA and a special effects company called Massive that could create convincing representations of thousands of actors — if you didn't look too closely and noticed that they all looked like Andy Serkis (joke).

Cartoon: *Toy Story 3*

It might seem old-school now, but *Toy Story 3* used a ton of groundbreaking procedural generation techniques to animate large-scale scenes. The scene where the toys find themselves in a garbage incinerator? Most of the trash was procedurally generated from the other trash around it. Similarly, the plastic bags wafting through the wasteland and how Barbie tore up Ken's vintage clothing collection (spoiler!?).

Art: *No Man's Sky*

Yes, it's a game, but Hello Games's *No Man's Sky* plans to procedurally generate an entire universe, from the flora and fauna, to the planets and stars. Then it generates alien landscapes and lets you land on them and walk about. Amazing.

howto

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

HARDWARE
IS MY HARD DISK DYING?

I'm trying to be a good boy and back up my files, like you are always telling us to, but I'm running into a problem. I'm using an external Western Digital 2TB drive and if I copy files across one at a time, it all works fine. But when I copy them over in bunches (a whole directory at a time, say) some of my files are corrupted with garbage. Sometimes they will open but show weird characters at the end. Others just refuse to open at all. I have checked for viruses and it isn't that. Does this mean that the drive is faulty?
Keith Jekes

Are you still running Windows 7? There have been reports of data corruptions with large scale USB transfers for years, but I'm yet to see one under Windows 8. This is most likely a problem with the USB interface. I suspect that when big transfers are buffered, certain circumstances can cause the buffer to be overwritten. This could be a buffer in system RAM, but it could also be on the drive itself. I've also heard people insist that taking the USB cable out and breathing on it helps by increasing the conductivity with the moisture from your breath. But none of them were sober. This isn't a hardware problem; it's a software one. A program is allowing the transfer buffer to be corrupted. X-Fast USB, which is bundled on some ASRock motherboards, is an example of this. It seems to speed up USB transfers by creating a layer of buffering in RAM, and disabling this has eliminated copy corruption on some systems. Now, let's turn our attention to your backup

Large scale USB transfers have been known to have problems in Windows 7.
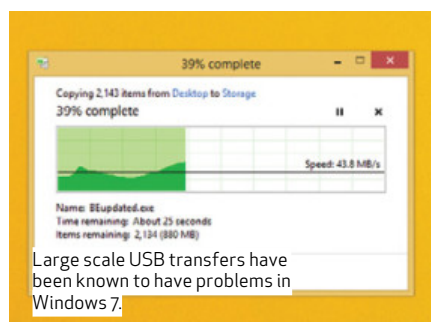
strategy. Manually copying files 'in bunches' is better than nothing, but not much. Instead, clone the entire partition using something like Macrium Reflect (**www.macrium.com**) or Acronis True Image (**www.acronis.com**). This doesn't rely on deciding whether a file is important or not (protip: they all are) and has the side benefit that byte-by-byte cloning utilities will normally bypass a lot of the possible sources of corruption that can affect file-based copies.
Luis Villazon

SECURITY
INTRUDER IN SECTOR 7!

I ran into trouble with some malware recently and ended up having to reinstall Windows to get rid of it all. After everything was restored from backup I was doing some double-checking to make sure everything was gone. In the Wi-Fi logs for my router, I found dozens of messages warning of intrusions. These were spaced just a few seconds apart and began almost from the moment I had got Windows working again! Obviously I shut everything down again but I am unsure what to do to proceed. If the system is intruded as soon as I boot up, how can I install anything to protect myself? If I buy a whole new computer, would this even fix it?
Anthony Poel

As a general rule, we'd avoid reinstalling Windows to get rid of malware. And if you do, restoring your backup is asking for trouble, because you could be restoring the malware too.

Those messages in your router logs are warning about attempted intrusions that have been rejected. If the intrusion had been successful, the router would (by definition) never have noticed, and so there would be nothing

Shields Up! can check your network to see if it's vulnerable to attacks from the internet.

Blinking router lights aren't necessarily a sign of hacker activity.

"If the intrusion had been successful, the router would (by definition) never have noticed."

in the log. Intrusion attempts like this are really common — I've got four in my router log for today already. They are generated by botnets — PCs infected with malware that are co-opted into a distributed network that scans huge blocks of IP addresses, rattling the door handles to see if anything has been left unlocked.

Most modern routers will just silently ignore these requests, so the bot can't even tell whether there's another computer at that address. It sounds as if your router is already doing everything it needs to (although do make sure you have changed the router's admin password from its default). If you're still uneasy, check your security by running the Shields Up! test at **www.grc.com**.
Luis Villazon

NETWORKING
THOSE BLINKING HACKERS
How can I tell if someone is hacking into my Wi-Fi? I have a new router (recently replaced when we upgraded to fibre broadband) and I have seen some suspicious activity. The Wi-Fi light blinks when none of our PCs are on, for example. If I look at the DHCP list on the advanced page, it shows some computers that I don't recognise. Should I be worried?
Austin Blake

Probably not, but this level of caution is sensible. Check you are using WPA or WPA2 security on the Wireless Summary page. WEP is the Wi-Fi equivalent of the lock on the bathroom door: it won't keep out anyone that doesn't respect your privacy already. The default for most routers these days is WPA/WPA2 mixed mode, which provides decent security and still

allows older devices to connect. If you're already using this, change the password, to be doubly sure, but we're pretty sure you're fine.

Of course, even completely open Wi-Fi isn't necessarily a cause for concern. Otherwise, how would cafes and shops be able to offer it? Letting someone on your Wi-Fi only guarantees them access to your internet connection and your local area network. It doesn't let them onto any of your actual computers unless you have enabled guest accounts, have easy-to-guess passwords, or are running unpatched versions of Windows with security vulnerabilities.

Probably the easiest way for a hacker to get into your system is to access the

router configuration page and change the DNS records so that **google.com.au** actually points to a webpage of their choosing that downloads a trojan to your desktop. That's why it's at least as important to change the admin password on your router, as it is to change the Wi-Fi password. Leaving it as 'admin' is asking for trouble.
Luis Villazon

LINUX
BROKEN BOOTLOADER
I have an old Windows XP laptop on which, a number of years ago, I installed Linux Mint 8. Yes, I said it's old! I now want to upgrade to Mint 15 for which I have the install disk. I've reformatted the old partition containing Mint 8, in preparation for replacing it. However, now when I reboot the laptop, Grub gives me a message "Error 17" and it appears I can't re-attempt the boot from this point. I suspect I shouldn't have deleted the partition containing the first option in the boot list — how do I get out of this problem please? I don't have a rescue disk for the Windows XP even if the laptop's dual-boot mechanism would let me use it, and I'm anxious to avoid rebuilding the hard disk, for which I have the recovery disks.
David Bew

As you suspect, you appear to have removed the partition containing files used by Grub to boot the computer. The initial Grub boot code lives in the first block of the disk, the Master Boot Record (MBR) but this then calls other code from that partition, which is why Grub loads but then shows you this particular error. There wasn't any need to delete the partition to install a newer Mint, you could have simply booted into the newer Mint installer (although why version 15 and not the
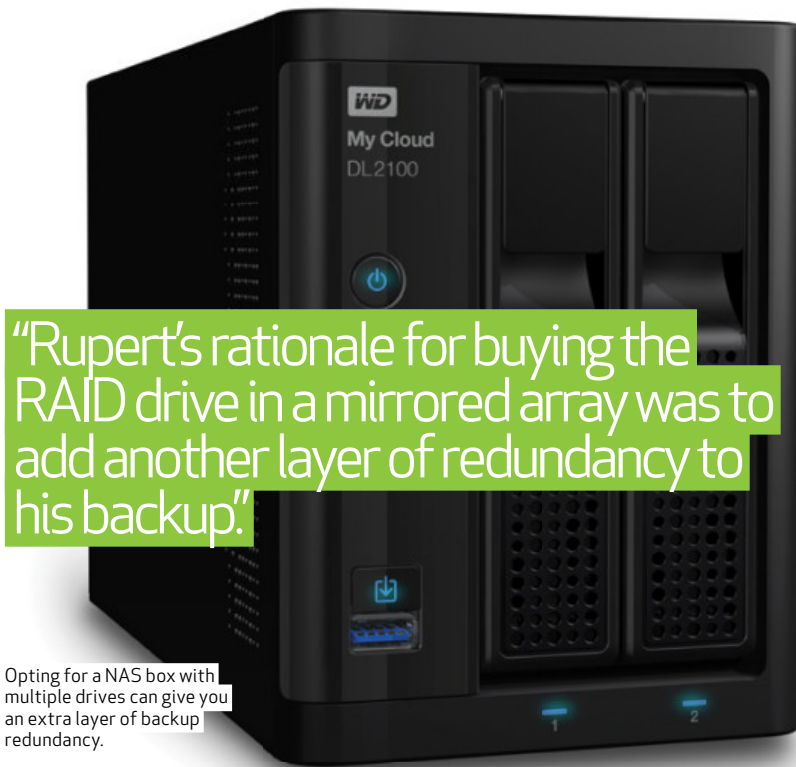
Booting from a live Linux disc lets you circumvent a corrupted bootloader.

how to » quick tips

"Rupert's rationale for buying the RAID drive in a mirrored array was to add another layer of redundancy to his backup."

Opting for a NAS box with multiple drives can give you an extra layer of backup redundancy.

current 17.2?) and told it to install on the Mint 8 partition. However wonderful hindsight may be, it's not a good bootloader so you need to fix this.

The lack of the partition only stops hard disk booting, so you should still be able to boot from the Mint disc and install the later version, which will include a new bootloader, which will enable you to sidestep the problem. Your other option is to restore the Windows bootloader, although this only makes sense if you have no other Linux distros on the disk. Boot from your recovery disc and enter the Rescue shell and run: `fdisk /mbr`

This command is specifically for

Windows XP, later Windows versions used different commands. If you don't have your Windows CD to hand or you would prefer a graphical method, download Rescatux from **www.supergrubdisk.org/rescatux**, burn it to a CD and boot from it, instead. You'll need the beta version (currently 0.32 beta3). After booting you will see a button marked 'Restore Windows MBR' — you may need to scroll down to see it. After using this, your computer should boot from Windows as normal, then you can proceed to install Linux at your leisure.
APC team

Grab the smartmontools package to diagnose disk problems in Linux.

BACKUP
EXTERNAL HARD DRIVE UPGRADE QUESTIONS

I want to upgrade to a larger external hard drive. I've decided that 3TB is more than sufficient, but wonder if you'd recommend purchasing a single 3TB drive or investing in a 6TB model, such as the Western Digital My Book DUO that comes with two 3TB drives that can be arranged in a RAID Array?
Rupert Tesche

Rupert's rationale for buying the RAID drive in a mirrored array was to add another layer of redundancy to his backup — if one physical drive failed, the other would still pick up the slack. That's all well and good, but we'd recommend keeping the two 3TB drives separate. Mirrored arrays mean that changes on one drive are immediately reflected on the other, so if you accidentally wipe data from one, it's removed from the other too. You also have the option of using each drive independently of the other. You could, for example, back up to each drive alternately, so you effectively get two independent backups for the price of one. That means if you find a file was accidentally deleted before you backed up, you can recover it from your other backup, giving you an extra layer of data protection.
Nick Odantzis

LINUX
DRIVING SLOWLY

The hard drive in my Ubuntu system seems to be running slower than it used to. Is there a program I can use to measure its performance? I realise that it would be more useful if I had done this when I got the computer in the first place so I can compare, but can anything help?
Eric Foster

The hard drive itself is unlikely to slow down unless there's a fault with it. You can check for this with `smartctl`, part of the smartmontools package by running the following: `$ sudo smartctl --test=long /dev/sda`

It will tell you how long the test will take to complete, wait that long then run: `$ sudo smartctl --log=selftest /dev/sda` to see the results. If you are feeling impatient, you could use `--test=short` instead, but this will only save you time if it shows a fault, otherwise you will need to run the long test to be sure.

As far as speed testing is concerned, `hdparm` performs basic throughput tests. It passes the device node of a partition that contains a Linux filesystem, like this: `$ sudo hdparm -tT /dev/sda2`

For a far more comprehensive test, you can use bonnie++, which should be in your distribution's (distro) package

manager: `$ bonnie++ -d / directory/to/check`

The directory can be anywhere on your filesystem but it's best to use an empty directory created for this purpose. If your distro installed the program in `/usr/sbin`, you may need to give the full path, `/usr/sbin/ bonnie++`, to run it. Bonnie++ isn't meant to be run as root, if you do it will insist you provide a user name with the `-u` option. These tests should be run while nothing else is using the disk, otherwise they will show a lower result than they should. Bonnie++ gives detailed benchmark results which are only of any real use when you have something to compare them with, like the results from a test when the drive was new. However, it can also be useful when you are trying to improve the performance of your drive, so see whether the subjective results are real.

If `smartctl` showed no errors, and particularly if `hdparm` gave a decent result, it may be that you are seeing a slowing down of the filesystem rather than the drive holding it. This can happen if it becomes fragmented, particularly if you are working with large files. While Linux filesystems are good at keeping themselves defragmented, if the filesystem is nearly full fragmentation is almost inevitable. If you are using an ext4 filesystem, the default for most distros, then you can check for fragmentation with e4defrag: `$ sudo e4defrag -c /dev/sda1`

Passing a device like this checks the entire filesystem, or you can give a directory to check only the files in there. If it's your home directory, you don't need to use sudo . This command checks for fragmentation, if it reports that its fragmented too much, (don't do this on an SSD) run the command again without the `-c` option.

MAC
WHY DOES MY MACBOOK OVERHEAT?

My 2007 MacBook Pro seems to abruptly overheat, even when I'm not doing anything that intensive. I can be watching a video for a couple of hours with the fans whirring silently and then, after I quit, the fans will spring into life and blast away at full speed, staying at this level until I shut down. Other times, my MacBook runs the fans at full speed even from startup… help!
Brian Halliday

If the air coming out of the vent feels cool, this might be a problem with the fan regulator rather than overheating. If your Mac isn't running hot during video playback then it isn't likely to suddenly heat up just because you've closed the video. OS X doesn't run the fan slower than it needs to. It is, however, common for fans to get stuck

A corrupt search history can cause problems – you can clear it on this page.
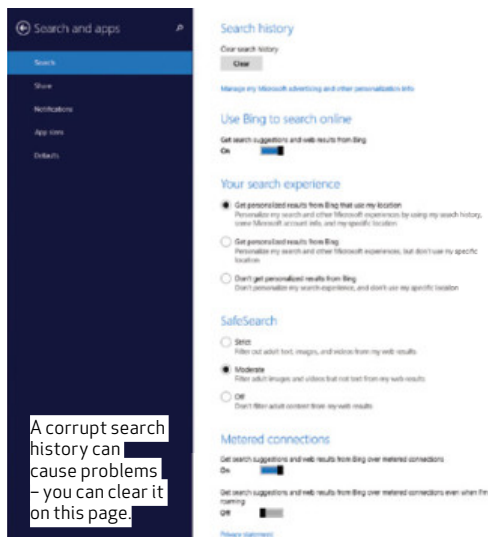
at maximum speed; it's nearly always fixed by resetting the System Management Controller (SMC). On the 2007 MacBook Pro, which has a removable battery, the procedure is to shut down the Mac, disconnect the MagSafe connector, take out the battery and hold the power button down for five seconds. Then put the battery and MagSafe connector back in and restart.
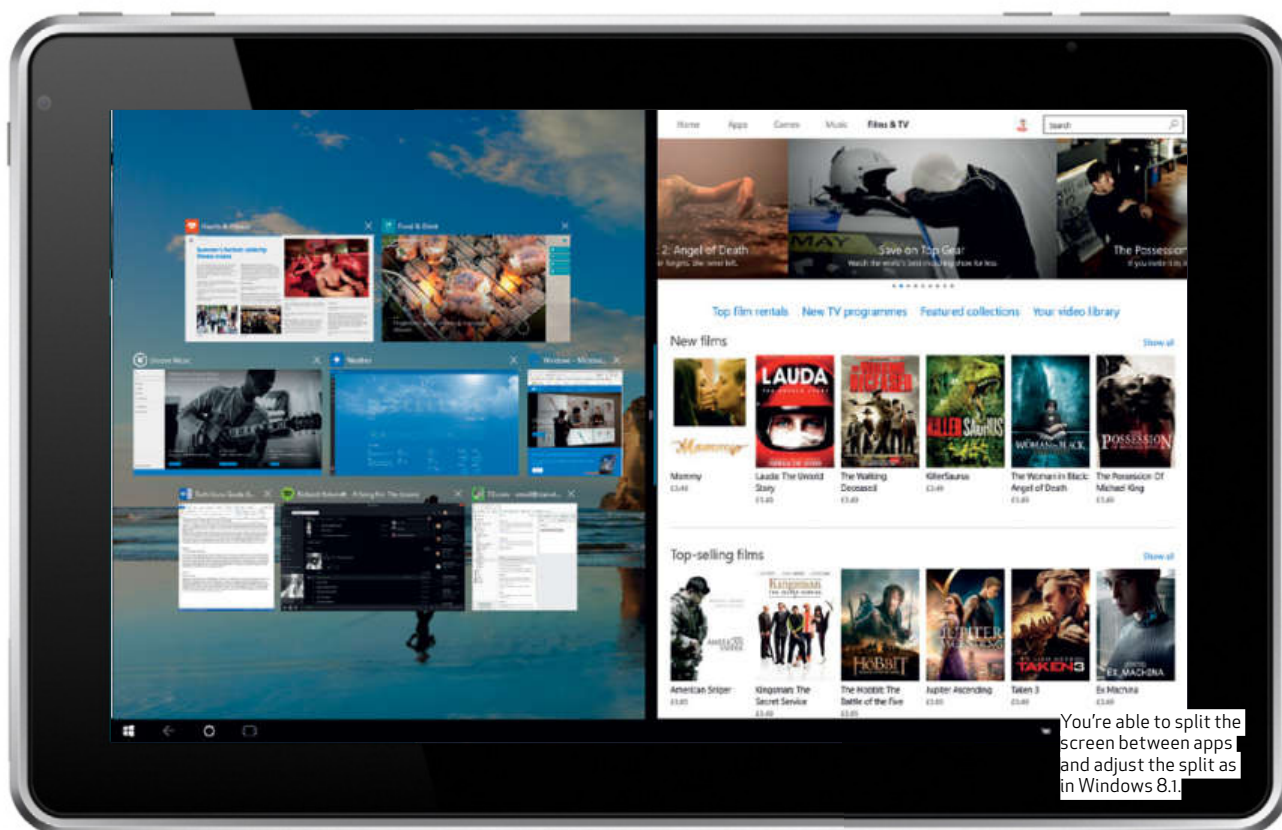Luis Villazon

WINDOWS
PANEL ACCESS

I was very interested in using Windows File History because I've always been jealous of Mac users and their Time Machine backups. Unfortunately, I can't get it to work. I can start File History, but when I try to run the 'Restore your files', I get the error "Cannot access immersivecontrolpanel". I've tried making sure File History wasn't still running, as well as rebooting, and so on — still no joy. So, what's up with that?
Rich DiMarco

Ah yes, this isn't actually a problem with File History; you can also run into it with Windows Update, Firewall and other things. It's Search that's borked. To fix it, you need to clear your search history. Open the charm bar and click 'Settings > Change PC Settings > Search and apps > Clear search history'. In the unlikely event this doesn't work, you'll have to rebuild the search index manually, via Indexing Options in Control Panel. (The best way to find Indexing Options is to open Control Panel and type 'indexing' into the search box at top right.) Now click 'Advanced' to bring up the Advanced Options dialog and then 'Rebuild' on the Index Settings tab. This will fix Search, so you can access File History from the Windows search bar. Alternatively, you could just do it directly from Control Panel, now that you know how.
Luis Villazon

If your MacBook fans suddenly go haywire, it's time to reset the SMC.

You're able to split the screen between apps and adjust the split as in Windows 8.1.

Master Windows 10 on tablet

Windows 10's Tablet Mode (previously known as 'Continuum') ensures the new OS adapts to the device you're using.

Leading up to its launch, we've had unparalleled access to Windows 10 thanks to Microsoft's Insider program, which was essentially a way for developers and early adopters to try the system as it moved through versions.

Throughout this process, Microsoft talked about a new capability called Continuum. You'll notice that this name isn't used in the final version of Windows 10; instead the new feature is now called 'Tablet Mode'.

However, both names give a clue to what the new feature is designed to do, and that is provide a seamless experience for users of Windows technology. With more 2-in-1 PC/tablets being sold (as well as more standard laptops with touchscreens), Microsoft wanted to find a way for Windows 10 to adapt to its surroundings. And that's what we have with Tablet Mode. In a sense, it's Windows 10's answer to bridging the gap between touch and conventional keyboard and mouse use; something that didn't go down so well with Windows 8.

A TOUCHY SUBJECT

The problem with Windows 8 is that it was all about touch. Keyboard and mouse users were treated as second-class citizens. The enhancements in Windows 8.1 went a long way to solving these issues, with elements such as the taskbar appearing on top of the Start screen if you needed it to. The problems with Windows 8 ran deeper though, as it was a confused mess in other areas, such as the Charms. The Charms bar gets axed in Windows 10, but they still had a role to play for tablets and, in some ways, it seems retrograde to revert everything back to the Taskbar and Start menu. But in other ways it doesn't, and this is why Tablet Mode exists; it helps Windows 10 become touch friendly when you need it to, and non-touch friendly when you don't. It's also designed to bring a more consistent user interface across all Windows 10 devices rather than having dual Desktop and Start screen modes, as we had in Windows 8 and 8.1.

This process can be automatic. In simple terms, Tablet Mode detects whether or not a keyboard is attached to your PC. When the keyboard is detached, it becomes a tablet and this can automatically launch Tablet Mode. It is more user configurable than this, though – see the Tablet Mode settings box, on page 75, for more.

You can manually enable it should you want to. This might be useful if the detach doesn't work properly or you want to use your screen like a tablet (even if you've still got a keyboard attached).

As with most commonly used settings, Tablet Mode can be launched via a button in the Action Centre. Action Centre in Win 10 is designed to be the home for Notifications and to do anything that doesn't require launching the settings app.

Click the Action Centre icon in the Notification area to launch it and then select 'Tablet Mode' from the options at the bottom. It conveniently sits alongside other buttons you can toggle on and off such as Flight Mode, Wi-Fi, Location and Bluetooth, and is underneath any Notifications you get from apps.

THE MAIN EFFECTS

There are several key usability adjustments that Windows 10 makes when you go into Tablet Mode. Your

In Tablet Mode, the new Task View feature becomes a must-use rather than a nice-to-have.
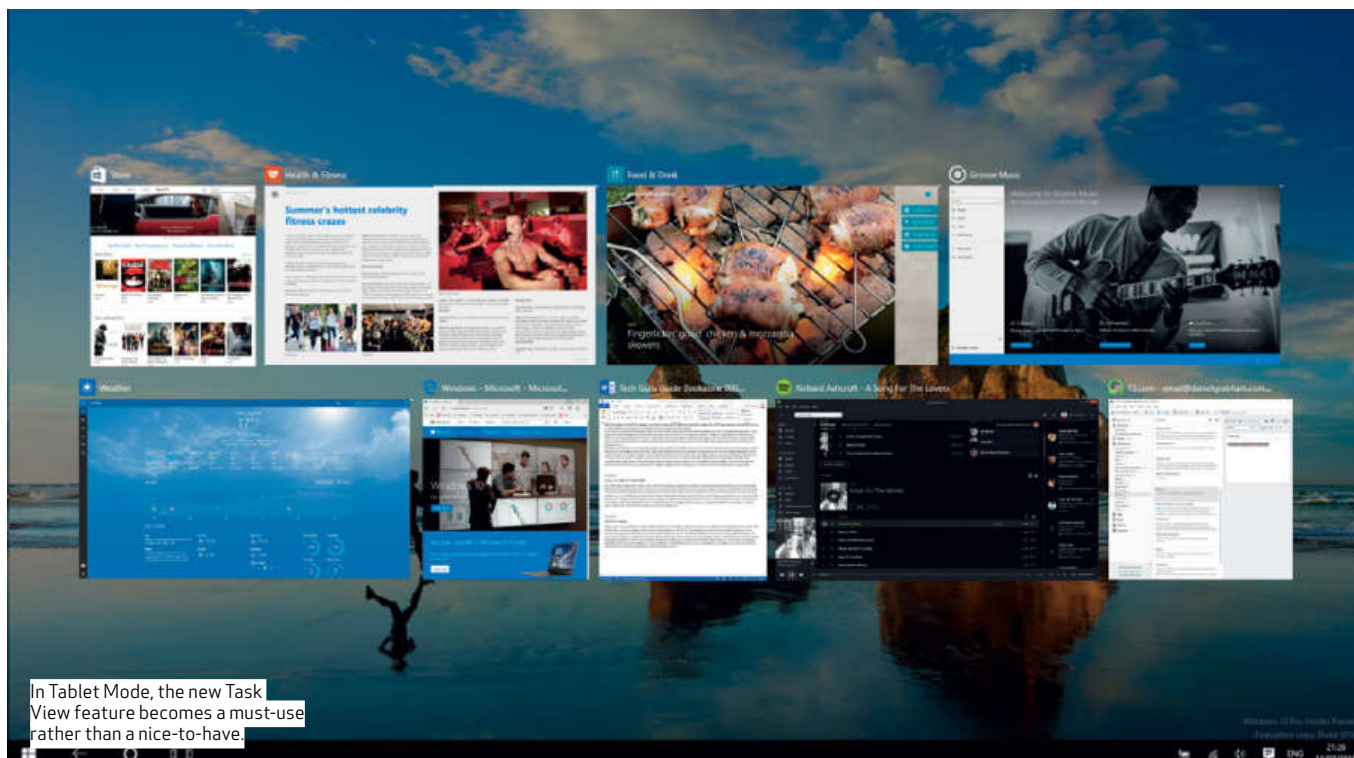
device automatically adjusts for touch input and your desktop and Start Menu change. Windows 10 doesn't go for a complete reintroduction of the Windows 8 Start screen, but it does something similar. The Start menu becomes full screen, just like it was in Windows 8 and is permanently open on your desktop, so it's more like an iPad-style home screen launcher in the background.

If you've already used the Start menu in Windows 10, you'll know how much it's changed from the version in Windows 7. The new Start menu has live tiles on the right-hand side. You can right-click any file, folder or app in Windows and select 'Pin to Start' to include it here. On the other side you get a list of recently used programs, as well as shortcuts to other key destinations, such as the Settings app and a shortcut to the File Explorer. You can also shut down, restart or put your PC to sleep from this menu, too; click 'Power' and another menu pops up with these options. The live tiles work in the same way as they do in Windows 8 so you can drag any of them around the menu should you wish to re-order them.

Tablet Mode introduces a modified version of this Start menu. The left-hand side of the menu now has three icons. The top 'hamburger' icon enables you to access your most-used apps. This part is more like the desktop version of the Start menu and your User Account is shown at the top — you can lock the screen or sign out here just as you could in Windows 8 and 8.1. This menu is joined by a Power button (which enables you to restart, shut down or sleep) and another icon at the bottom so you can scroll down through a list of your apps, not just the ones that are pinned to the Start menu. In Tablet Mode, you can also swipe up on the left side to open the All Apps menu, so you can browse your entire apps list. Tap a letter on the All Apps list to go to a letter chooser and quickly jump to another section.

If you're connected to a second

Search, Back and Task View buttons remain next to the Start menu by default in Tablet Mode.
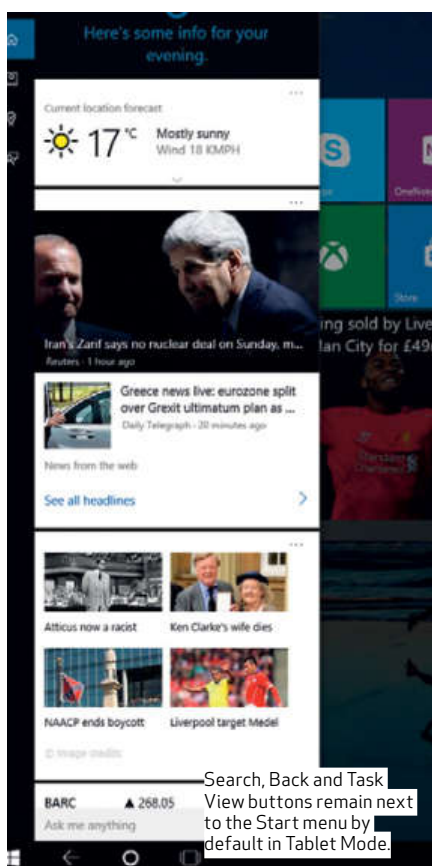
Do you need a tablet for Tablet Mode?

One of the clever things about Tablet mode is that it's completely automatic. But it doesn't necessarily need to be and you can start it manually. Bizarrely, it's not touch specific, so the option to use it is there even if you have a non-touchscreen device. We're surprised at this, but Microsoft must have decided it was impossible to implement in this way. While Tablet Mode isn't useful on a non-touchscreen device, it is something that could be used on a standard laptop, which doesn't have a detachable keyboard. How? Well, say you're doing a presentation or you want to use the touchscreen to choose music at a party; you can change your laptop from being a device set up for mouse and keyboard use into one where the touchscreen is the main method of control. In Tablet Mode you can toggle whether you want the app icons hidden on the Taskbar. For some reason hiding them is the default behaviour, but you can disable this.

display — which you might be with a convertible PC or tablet, such as the Surface Pro 3, the Start menu won't go full screen. Instead it will be the same size as normal and it also be constantly open. The other key thing Tablet Mode changes is how the Taskbar looks. It becomes simpler in terms of features — although you can still get to everything you need. It spaces out the taskbar icons in the Notifications area and removes the ones you don't need (mostly unnecessary third-party icons). You just see Wi-Fi, battery, sound and the Action Centre icon left. Plus the ever-present clock, naturally. The App icons are hidden by default, too. We're not sure why this is, but you can turn them back on if you wish. In fact, you can turn any Taskbar feature back on that Tablet Mode removes by default — the app icons, notification icons, touch-keyboard button and language switcher. The touch keyboard icon disappearance is a bit of a strange one, but we guess the reason is the keyboard still appears automatically if you tap into a text box, browser address bar or similar. So the button not being there isn't a huge issue.

WHAT'S MORE?

On the other side of the Taskbar, the Start icon is now joined by a back button, so you can cycle back to previous apps. If you were in the Start menu and then launched an app, tapping the back button takes you back to the Start menu. It's a much more phone-like experience. There's also a Search icon as well as the Task View button. Search in Desktop mode (which incorporates the Cortana voice

assistant) is via a search bar. In Tablet Mode it is an icon by default, offering a more simplistic look.

Apps are full screen in Tablet Mode, whether they're Windows Apps you download from the Windows Store or traditional desktop apps, such as Microsoft Word. This isn't as ridiculous as it sounds — we're all used to using tablet apps on things such as iPads, and Microsoft is trying to appeal to those sensibilities. It does take a little getting used to at first, however. In Tablet Mode you're also able to quit both desktop and new Windows apps in the same way you could in Windows 8; by dragging them down to the bottom middle of the screen. Windows apps also have their X icon hidden for this reason (though if you happen to be using a mouse in Tablet Mode these will reappear).

To move between apps, Microsoft hopes you will use the new Windows 10 Task View feature. Using Task View is a lot more intuitive on a touchscreen device. On a laptop or desktop, Task View is rather secondary to just switching between open icons on the Taskbar or using Windows with the Tab button (Alt-Tab still works as well, as you'd expect).

Task View is a fine new addition to Windows 10. However, you can't say it's a groundbreaking new feature, as it's mostly a repackaging of what has gone before. But what is new is its addition to the Taskbar. This brings it to the attention of more users. Until now, many people who used Windows wouldn't have even realised that pressing the Windows button with the Tab one could even take them to an

interface to flick between apps. Fewer still will have realised there was a way in the touch version of Windows 8 (not 8.1) to switch between app screens — flicking in from the left of the screen brought up a switcher menu. As with the Charms menu on the other side, it was underused and is now long gone, so it's good to have an

Tablet Mode makes the Start menu go full screen.
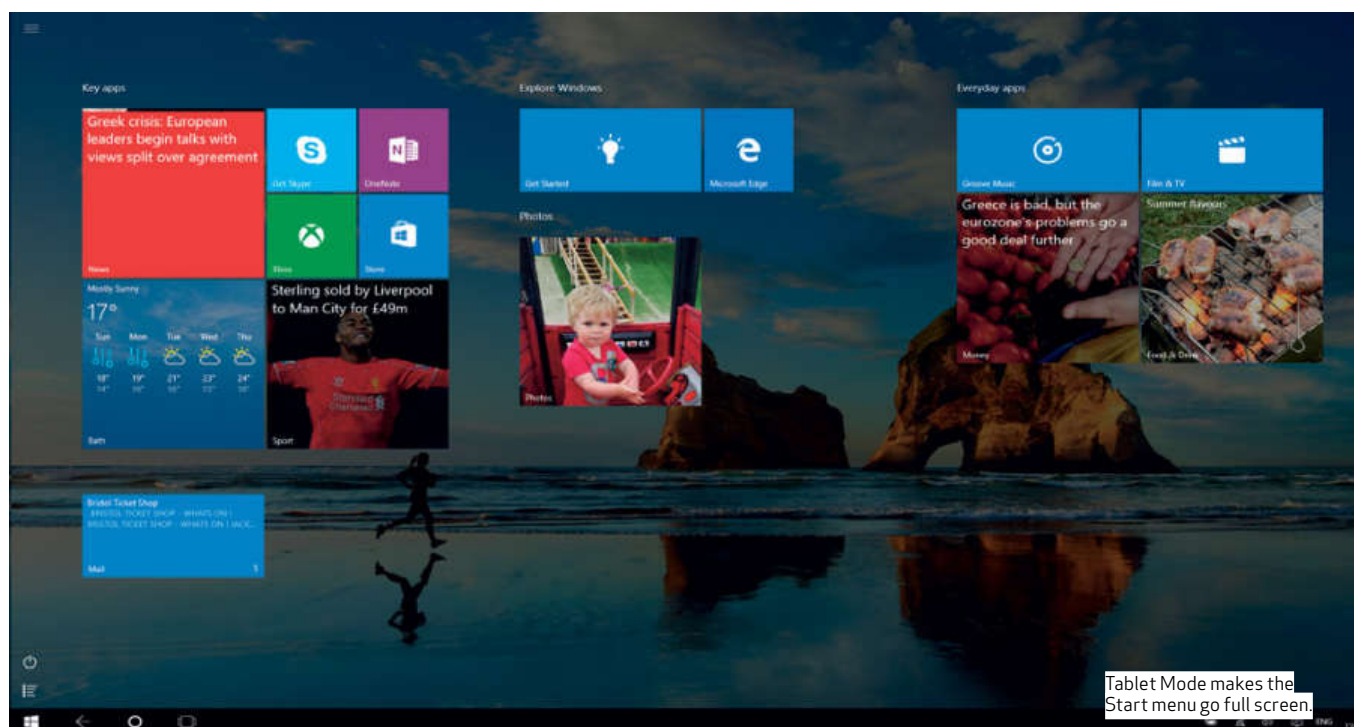
Apps are full screen by default. This is the default Weather app, but desktop apps such as Microsoft Word also go full screen by default.

even better feature to replace it with.

But, it's not true to say that Task View doesn't have any new features, since Task View also includes a Multiple Desktops feature (though it's only available in Desktop mode). While this is a new feature to Windows, it's not a new feature to computing in general; for example it's been featured in Apple's OS X operating system for several versions. Multiple Desktops are intended primarily for work, where you might have your email open on one screen, a spreadsheet on another and so on. To prevent distraction, you can open different apps on different desktops, so you can move between the desktops using Task View and close the extra desktops when they're no longer needed.

SNAP TO IT

Another change to app behaviour in Tablet Mode is the way you snap apps to the sides of the screen. As was possible in the Windows 8's Start screen, you can pin two apps side-by-side in Tablet mode. And as in Windows 8.1 (but not original Windows 8) you can adjust the split. Simply drag the bar that runs down between the two apps. Aero Snap in Windows 10's desktop mode now enables you to do a four-way split, but you can't do this in Tablet Mode (we really like the capability to do it in Desktop mode, though).

If you used touch back in the Windows 7 days, you'll know that using a touchscreen with the desktop was a far from pleasant experience. It was really hard to hit the target you wanted with your finger and it just wasn't a very good experience. Things are really different in Windows 10. There's much less uncertainty in the touch. This is due partly to much better touchscreens being around than when Windows 7 was released. But Microsoft has also worked hard to make the desktop an environment where touch can thrive rather than be 'second best' to keyboard and mouse.

Tablet and 2-in-1 devices (with a detachable keyboard) are still in the minority when it comes to the number of Windows devices out there, and it's hard to see that changing in the short term. That's why Windows 8 was such a mistake for Microsoft; it went too far towards catering for touch-based PCs that are a small percentage of all the Windows devices sold. And that's also why Tablet Mode is such a great addition for Windows 10. It's there when you want it and gone when you don't. And for those of us with hybrid tablet/laptop devices detaching the keyboard and transitioning to Tablet Mode is a seamless experience. No longer is it just a case of the hardware being touch-ready, now Windows is as well. With Windows 10, Microsoft has worked hard to bridge the gap between desktop use on traditional PCs and tablets and it has succeeded. ■

You can adjust the default behaviour for Tablet Mode within the Settings app.

Tablet Mode settings

Tablet mode can be automatic when you detach a keyboard, but it doesn't have to be. Within the excellent new Settings app, go to 'System > Tablet Mode'. You'll see a toggle switch to switch Tablet Mode on or off, but it's the settings underneath that are more interesting. You can choose what you want Tablet Mode to do when you first sign into your PC. Tell it to remember to switch Tablet Mode on or off depending on what you used last. Or select to always go to the Desktop or to automatically switch to Tablet Mode (so if your PC detects a keyboard it still won't switch). The option below this enables you to control how automatic Tablet Mode is. You can make it automatic when a keyboard is detached, or you can choose to be prompted via a pop-up on the desktop. And finally, you can choose not to be asked and for it not to be automatic (but you can still invoke it manually).

Backup in Windows 10

Zac Storey shows you how to backup your important files using Windows 10.

A
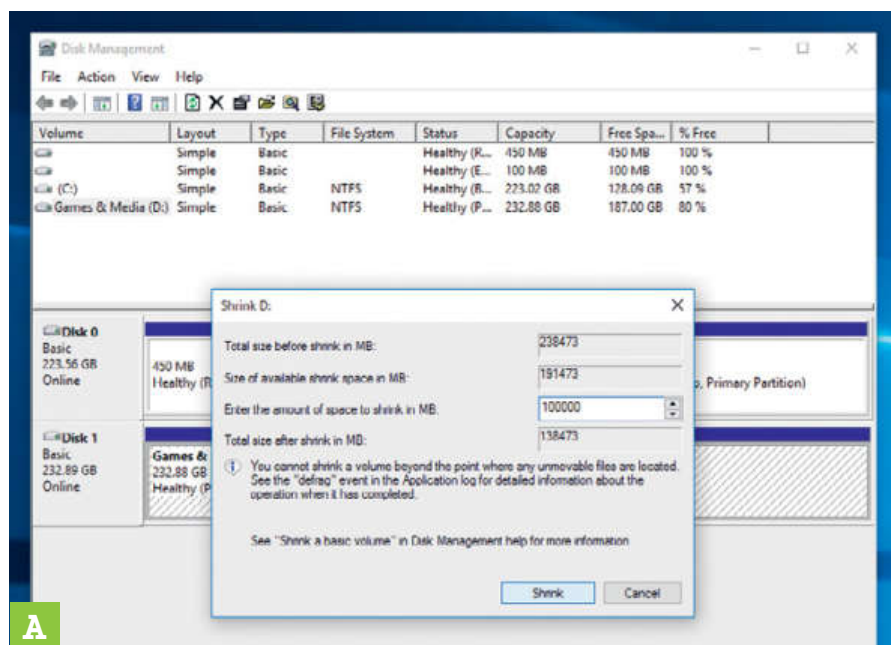
Today is an incredible time to be alive. Over the last 10 years the world has created a torrent of digital information. In fact, if you ask Cisco, we'll have passed the threshold of consuming over a zettabyte of information by the end of 2015. That's a billion terabytes. With more of us opting to sack the 5.25-inch bay in favour of USB installs and a cleaner, tidier rig. It'll only be a matter of time until disks go the way of the dodo. Following floppy disks, LPs and photo albums into early retirement; reserved only for the hipsters and purists amongst us who still value a connectivity free world.

But ultimately, in this age of wonder, there's a terrifying fragility to all of the memories, music, files and documents we hold dear. It's never been more important to run and maintain multiple backups. In this guide we'll show you how to ensure the continued security of your files from the inevitable monster that is file degradation, corruption and general accident.

1 PREPARING YOUR PC
The first thing you need to consider is, what do you want to back up and how are you going to secure those files against their inevitable demise? In our case we will be utilising a Windows 10 operating system and the integrated Windows Backup feature.

We'll be doing a simple backup of our C: drive and our documents and that's it. After all, Steam games are already safely secured in the cloud, ready to re-download.

2 THE PERKS OF HARD-DISK PARTITIONING
You should all be aware of creating hard disk partitions already. The general principle is pretty simple. Either through utilising partitioning software or multiple hard drives you can keep your main OS on one partition and your games and other programs on another. Not only does this potentially protect you from some minor viral infections, but it also helps to keep your PC organised and easier to back-up as well.

3 SHRINKING A HARD-DISK PARTITION
To shrink or create a hard-disk partition, click the Start menu then type `partition`. Windows should bring up a program that says "Create and format hard disk partitions". Once in here you can format a new drive, or shrink an existing one. In our case, we're going to shrink our games drive by 100GB to create space for our new backup partition. Right click on your chosen drive or partition and select shrink volume. Then input in megabytes how big you want your new partition to be, and select Shrink [Image A].

Why is Image so important?

Windows 7 System Image Backup is quite possibly one of Microsoft's best features. It allows enthusiasts a way of backing up and restoring systems effectively and quickly when they're prone to corruption or data loss. Particularly handy when running a RAID 0 (striped) environment. Even though SSD reliability has increased quite dramatically, you still don't want to be running a RAID 0 array without a back-up, especially if you're storing valuable information on it.

Microsoft removed Windows 7's backup feature from Windows 8.1, forcing users to go elsewhere for their backup solutions. This was particularly annoying considering its rationale for the removal of this feature was that if you had any OS problems, you could fix them with a simple USB media key or a Windows refresh. It's back in Windows 10.

4 CREATING A HARD-DISK PARTITION
Once you've successfully shrunk your hard drive, right click the black Unallocated space and select 'New Simple Volume'. Hit Next, and then input how many MB you want your new volume to be, then hit Next again. Here you can assign the drive a letter (from A-Z) and hit Next again. At this point you want to keep the file system as NTFS, the Allocation Unit Size as Default and then give it a label (such as Backup). If you're running an SSD, always select 'Perform a quick format', then hit Next to finish [Image B].

5 SETTING UP WINDOWS BACKUP
Once you have your backup partition set up and formatted, click the Start menu, then 'Settings > Update & Security.' Once here select the third option down — Backup. Once the new window opens you want to use the 'Back up using File History' option. To do this, hit the add drive button, then select your new partition. Windows will now give you one tick box that says automatically backup my files. Click the More options

B
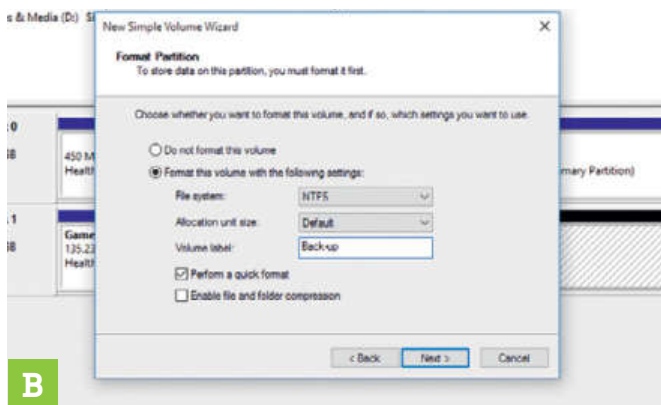
link below. As you can see this will be backing up all of your individual personal files, such as music, photos and documents, but not a lot else, you can also choose how often you want it to backup your files.

6 SETTING UP AN IMAGE BACKUP
Although this is a great way to ensure you don't lose any cherished memories, if your operating system crashes it'll be less than helpful. While on the Backup page, select the 'See advanced settings' link at the bottom of the new window. Then at the bottom left hand side of that window hit 'System Image Backup.'

7 WINDOWS 7 IMAGE BACKUP RETURNS!
Once here you'll want to select the 'Set up back-up' option. Then it's simply a case of choosing which hard drive or partition you wish to save an entire backup of your OS to. Hit Next, and then decide what files you want to back-up. You'll create a System Image in this process.

8 SCHEDULING BACKUPS
Once you've finalised what files you wish to backup, your next choice is to arrange a backup schedule. Your PC needs to be switched on for this backup to occur. Hit the 'Change schedule' link and set when and how often you want to backup, then select 'Save settings and run backup' and you're done [Image C].

9 ON-SITE SOLUTIONS
A popular solution today is to invest in either a Network Attached Storage device or a USB hard drive that you can plug directly into your router, the latter being less useful, but both provide an additional way of backing up your files to protect your systems and your digital life.

10 OFF-SITE SOLUTIONS
And finally there's the off-site solution. The infamous cloud. Uploading your backups to the cloud, whether they're personal files such as photos or documents or even entire operating systems is now entirely possible. Solutions such as Google Drive, Microsoft Onedrive, Dropbox, and Acronis are great examples of these.
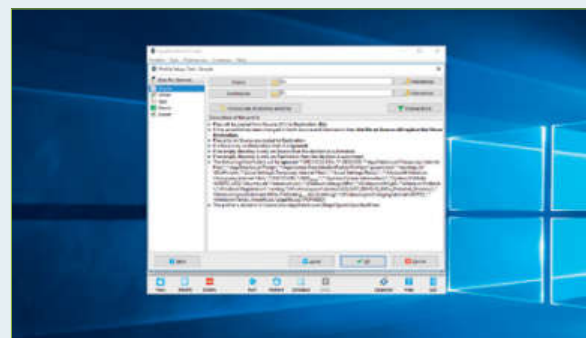

**C**
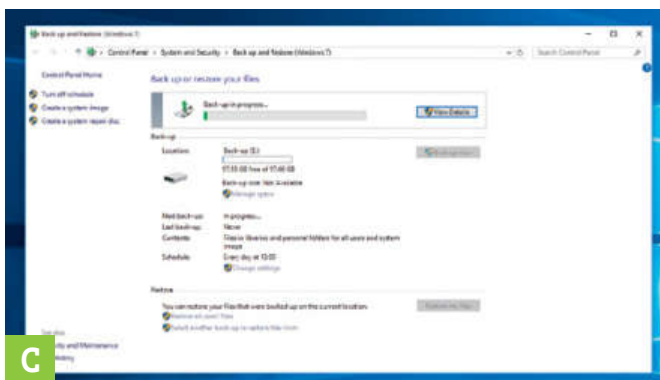
Backup alternatives
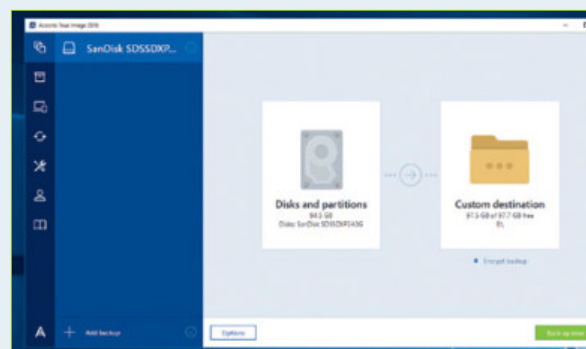
Acronis Software
If you're looking for an alternative premium backup solution Acronis might be the one for you. Although it comes at quite the monthly cost, Acronis provides its customers with online cloud storage and syncing across multiple devices, providing of course your connection speeds are viable.

Sync Back Free
If you're feeling a little bit on the cheap side and don't fancy forking out for paid backup software Sync Back Free might be the solution for you. Although it's free and comes with a rather clunky interface, a massive perk is the fact that it does not use a proprietary format. Ideal for backing up media files, it also doesn't create any bootable media or system image files.
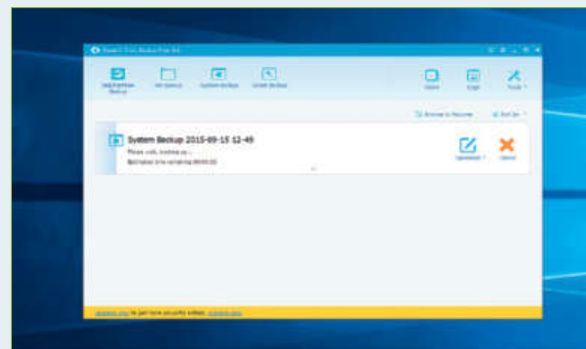
EaseUS Todo Backup Free
As the name implies EaseUS is another free alternative. Providing both free and premium products, EaseUS can create backups of your entire system and comes with a user friendly interface layout, with enough features for the hardened tech junkie. ■

Share iOS apps, games, movies & more

Rosemary Hattersley helps you set up Family Sharing from your iPhone to share your purchases.

Many families have several iPhones and iPads, so it has always seemed rather unfair that each person has to buy their own copy of books, apps and games. After all, if you were using the family games console you could all take turns playing the same game without everyone having to purchase their own separate copy.

Thankfully, iOS 8 introduced Family Sharing, which lets up to six people share apps, games and books, plus photos and a family calendar. It works for items you've already bought, and any group member can share content with any other person in the group. It's also a nice alternative to having to

buy iTunes gift cards, because you can link your children's accounts to yours and allow or prevent purchases as you want.

You can't share everything, of course. Some items are explicitly set to be non-shareable, such as movie downloads you can't download to more than one device. In practice, it's mainly apps that have this restriction on them.

Most books, games and music can be shared, and there's also a new cost-saving app bundle option in the iTunes Store. There's a limit of six people per Family Sharing group and 10 devices that can share content on them at any one time.

Family Sharing lets up to six people share apps, games and books, plus photos

1 THE ORGANIZER
Family Sharing needs to be set up by the Organizer — essentially the account holder and the one who will be responsible for paying for apps and games. You can either set up Family Sharing when first setting up your iPhone, or do so later by going to 'Settings > iCloud' and tapping Family. An overview screen summarises what Family Sharing enables you to do. Tap 'Get Started' and then confirm you want to use your existing Apple ID and account.

2 CONFIRM OPTIONS
The Organizer manages the Family Sharing account and controls whether younger users can buy particular apps and games. Check and confirm the account's card details, then confirm that you accept responsibility for purchases made using it. You can then opt to share your location with group members using the Find My Friends app. This can be useful for keeping an eye on your kids' or their iPhones' whereabouts. Tap 'Not Now' to skip this.
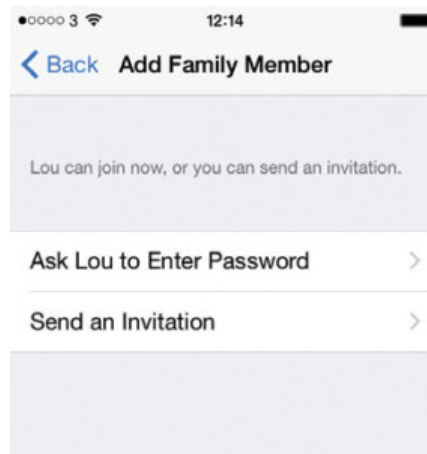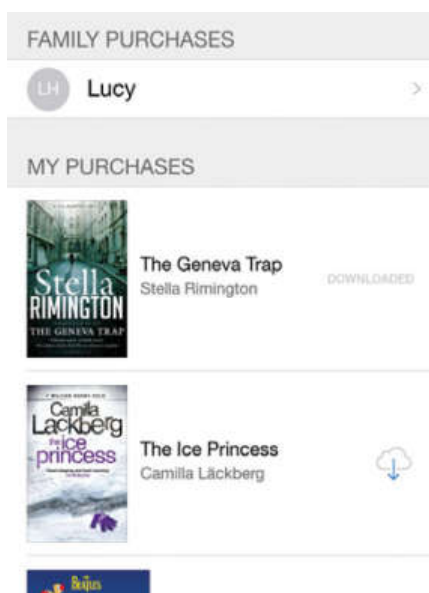
3 ADD MEMBERS
To create your family group tap 'Add Family Member' and type the email address of a person you want to add. Up to six people can be members of a Family Sharing group, but you can be a member of only one group at a time. If the person joining the group is with you, tap "Ask [name] to Enter Password" and then get them to type in their Apple ID password on your iPhone. Provided that their Apple ID and password tally they will immediately be added.

4 INVITE BY EMAIL

It's likely that some people you want to add to the group are not on the spot when you want to set it up, so you'll need to send their invitations by email. Type an email address on the Add Family Members screen, then tap 'Send Invitation'. Enter your Apple ID password when prompted. You'll then be taken to the Family Members page, where you can instantly issue further invitations by tapping 'Add Family Members' and entering each email.
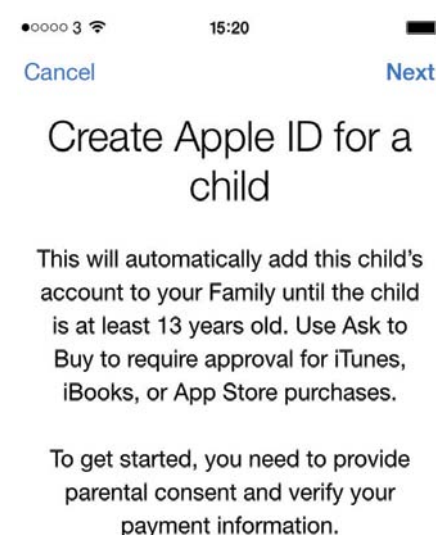
5 CONFIRM MEMBERSHIPS

Invitees will get an email outlining what Family Sharing is all about, with a link to confirm they want to join your group. They can join only if they aren't part of another Family Sharing group. Once they accept your invitation, you'll get an email, and their name will also appear in the 'Settings > iCloud > Family' list. Tap the name of any adult in the group list and then toggle Parent/Guardian on if you want them to be able to approve Ask To Buy requests.

6 ADD A CHILD ACCOUNT

Under 13s must have their own Apple ID (they can't use yours) to use Family Sharing, which you can create for them at this step. You need to set up the account for them using your payment details. Now add their birthdate, so you can control which age-appropriate content they can see. If they try to buy something, you'll get an Ask To Buy request — it'll be up to you whether to approve the purchase (with the payment coming from your card).

7 START SHARING

You can immediately borrow books, apps and games from group members by tapping the Purchased section of the App Store or iBooks, and then tapping a member's name to view what they've bought. It can take a couple of minutes for the content to appear in the list. If you spot something in another group member's library that you want to use, just tap it to download it to your own iPad. You'll see a message on items that can't be shared.
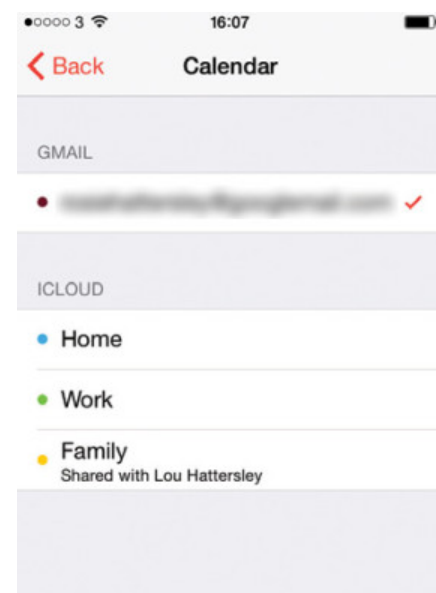
8 SHARE PHOTOS

You can share photos with your group by turning on iCloud Photo Sharing in 'Settings > iCloud > Photos'. Now go to the Photos app, tap 'Shared > Family' and then the "+". Tap to select any photos from your iPhone's gallery that you want to include, then tap Done. Add a caption if you wish, then tap Post. If you previously used Photo Stream to share albums, you'll see these appear alongside the Family and other shared albums in iCloud Photo Sharing.

9 SET UP FAMILY EVENTS

Family Sharing is also very useful for reminding family members about get-togethers and other events. This works only if you sync the Calendars app under 'Settings > iCloud > Calendars'. If you don't have this option switched on, you must send an email invitation to attendees from within the Calendar app. Once done, just tap Calendar and check the appropriate family members' names to share the event with them to appear in their calendars.

Hacking Notification Center

Not just a bit of wasted real estate on the right of your screen, the Mac Notification Center can actually be useful. Matthew JC. Powell shows you how to use it.

When Apple released OS X 10.7, Mountain Lion, in 2012, one of the (literal) banner features was Notification Center, a column added to the right hand side of the Mac's screen on which all manner of alerts and other info from various applications could be found. Originally an iOS feature, it hasn't really found many fans among OS X users.

But it doesn't have to be that way. With a little tweaking you can use Notification Center like a sort of cork board, on which you pin notes to yourself. Notes that can activate applications, open URLs and more.

For this tutorial we're going to be using the Terminal to create these notes to yourself, but next time we'll show you how to write a standalone application using Automator to put a nice graphical gloss on the whole thing. It's best to start off with some understanding of what's going on though. So to start, open the Terminal. It's in 'Applications › Utilities', or of course you can just activate Spotlight and type the first few letters to launch it quickly. Next, you'll need to install a small utility called Terminal Notifier. To do this, type:

```
sudo gem install terminal-
notifier
```
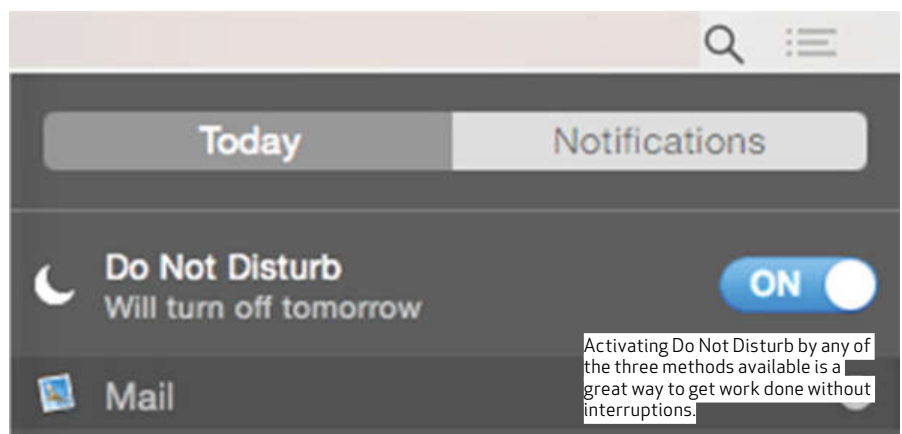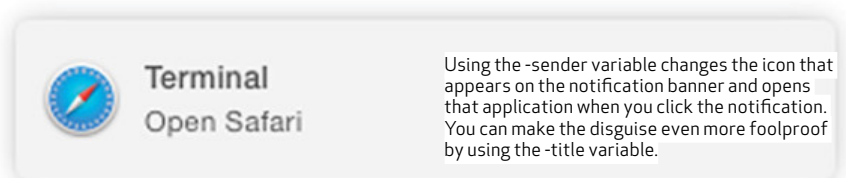
Hit return and then you'll be asked for your admin password. A few seconds later, you should be told that the software has successfully installed.

To make your first notification, type:

```
terminal-notifier -message "I
am very clever"
```

and hit return. You'll see your notification appear as a banner, and then disappear. If you open Notification Center by tapping on its icon in the upper-right corner of the screen, you'll find your message among the notifications from terminal-notifier, since all notifications are sorted according to the application that sent them.

To save yourself a lot of scrolling, you might like to open the Notifications pane of System Preferences and sort

Using the -sender variable changes the icon that appears on the notification banner and opens that application when you click the notification. You can make the disguise even more foolproof by using the -title variable.

Activating Do Not Disturb by any of the three methods available is a great way to get work done without interruptions.

```
The-Walrus:~ mjcp$ sudo gem install terminal-notifier
Fetching: terminal-notifier-1.6.3.gem (100%)
Successfully installed terminal-notifier-1.6.3
Parsing documentation for terminal-notifier-1.6.3
Installing ri documentation for terminal-notifier-1.6.3
1 gem installed
```
To send yourself notifications, you have to install a third-party utility called Terminal Notifier. Doing so will require you to use super-user mode (the "sudo" command) and enter your admin password. All going well, this is roughly what you should see.

Make Notifications stick around

When you receive a notification in OS X, it doesn't stick around long — five seconds, actually. Sometimes, though, you want them to stay longer than that, or even indefinitely.

To change the default time that notifications spend on screen, open the terminal and type: `defaults write com.apple.notificationcenterui bannerTime 30` and hit return. Then type: `killall NotificationCenter` and hit return. That will quit Notification Center and force it to reload with the new default.

Once you've done this, banners will stick around for 30 seconds. Obviously, adjust that 30 to whatever number of seconds you want.

If you want notifications to stick around until you click on them, open the Terminal and type: `defaults write com.apple.notificationcenterui bannerTime 86400`

Then hit return, and repeat the steps above to Force Notification Centre to quit and reload its new default. Then, any notification you send yourself (as well as all others) will hang about until you click on them. Warning: that can get crowded.

Terminal
I am very clever

Success! The bare minimum requirement for a notification is that the -message variable must have a value. Everything else is optional.

the order in which applications' notifications appear. Put terminal-notifier at the top of the list.

Alternatively, you can fool the Mac into thinking that a notification has come from a different application. To do that, you simply type:

```
terminal-notifier -message
"Open Safari" -sender com.
apple.Safari
```

and hit return. Then a notification will appear in Notification Center sorted as if it came from Safari, complete with a Safari icon. If you click on it, Safari will open. The same is true for any application that you fake in this way.

You could, for instance, send yourself

```
terminal-notifier -message
"DEADLINE APPROACHING" -sender
com.apple.Pages
```

to remind yourself to get on with some writing you need to get done.

(Note that the value of -sender has to be the ID of the application, not merely its name. For most Apple applications, this will be com.apple. Applicationname, but the same is not necessarily true for all developers' applications. It's not even true for all Apple applications — for instance Contacts is com.apple.AddressBook. Good luck.)
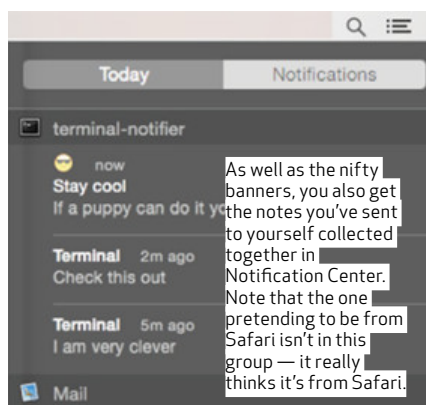
Of course opening Safari when you click a notification has limited utility. Generally speaking, when you open Safari it's because you want to look at a URL. There is a way to do that as well. Type

```
terminal-notifier -message
"Check this out" -open
"http://apcmag.com"
```

and hit return. Only the message text will be visible, but when you click on the notification it will open Safari (or your default browser) and load up the specified URL.

Unfortunately, the -open variable will only work if the sender of the notification is Terminal Notifier, so it doesn't work if you've faked the sender using -sender. Sorry.

There are other ways to pretty up your notifications, though, even if they do have a boring Terminal icon on them. For instance, type

As well as the nifty banners, you also get the notes you've sent to yourself collected together in Notification Center. Note that the one pretending to be from Safari isn't in this group — it really thinks it's from Safari.

The Notifications pane of System Prefs allows you to put the applications whose notifications are most important to you at the top of the list. For our purposes, put Terminal Notifier at the top so your notes to yourself are in one place.

Make Notification Center shut up

OK, so we've had lots of fun sending ourselves notifications and making them stay on screen as long as we want, but what about when there's work to be done?

Enter Do Not Disturb, the best thing Apple ever added to Notification Center. You can activate Do Not Disturb by going into System Preferences, opening the Notifications pane and clicking on Do Not Disturb at the top of the applications list. Or you can simply hold down the option key and click on the Notification Center icon in the top-right corner of the screen.

Bliss.
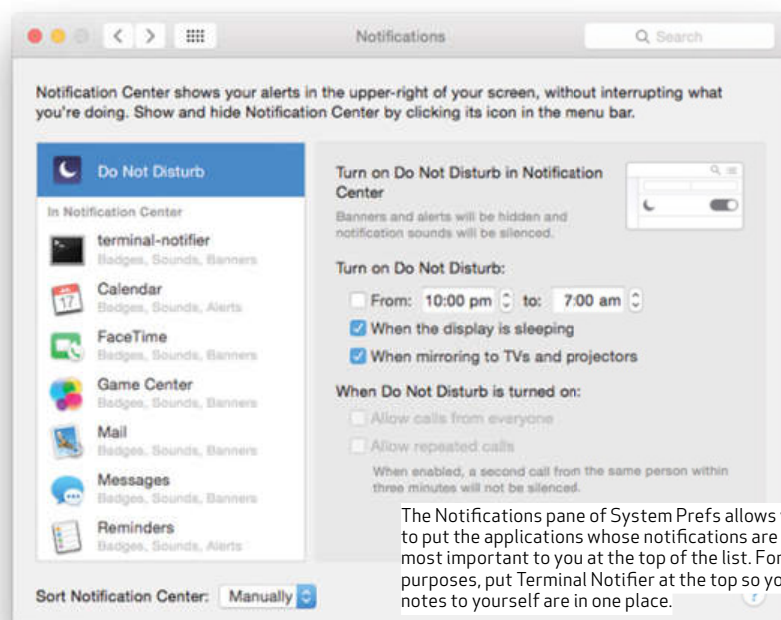
"With a little tweaking you can use Notification Center like a sort of cork board, on which you pin notes to yourself."

```
terminal-notifier -title " "
-subtitle "Stay cool" -message
"If a puppy can do it you can"
-open "https://www.youtube.com/
watch?v=GIHiuAzBXEg"
```

and hit return. All going well you should hear a noise, then when you click on the notification you should see an entertaining video of a puppy trying to climb into a refrigerator.

And yes, that's an emoji. It's a simple enough way to dress up an otherwise dull-looking notification.

Hopefully by now you're starting to see some of the uses that sending yourself notifications can be put to. You'll also notice that it's all a bit geeky and command-liney, which is why next time we'll build an application using Automator that will stop you having to open the Terminal.

Smarter sorting with macros

Helen Bradley shows how to combine macros and shapes to sort Excel data.

In many applications, clicking on a column heading will sort data in order based on the contents of that column. Click again and the data will sort in reverse order. This doesn't work in Excel but, by combining a macro with some shapes, you can create a solution that works this way. This month we'll show you how.

CREATE THE SOLUTION

Start with a worksheet that contains a table of data starting in cell A1 and with the column headings in row 1. Choose 'Insert > Shapes' and select the rectangle shape. Draw it over the first column heading so it is the size of the cell below. Right click the shape, choose 'Size and Properties > Properties' and enable the Move and Size with cells checkbox. Type the name of the column heading into the shape. Repeat and add rectangles over every column heading.

Open the Visual Basic Editor by choosing 'Developer > Visual Basic'. Add a module by choosing 'Insert > Module' and type this macro text into the module before exiting back to Excel:

```
Sub smarterSorting ()
    Dim ourDataRange As
Range
    Dim sortCol As Range
    Static colSortOrder As
Integer
    colSortOrder =
(colSortOrder Mod 2) + 1
    Set ourDataRange =
Range("A1").CurrentRegion
    Set sortCol =
Range(ActiveSheet.
Shapes(Application.Caller).
TopLeftCell.Address)
    ourDataRange.Sort
Key1:=sortCol,
order1:=colSortOrder,
Header:=xlYes
End Sub
```

ASSIGN THE MACRO TO SHAPES

Right click each rectangle in turn, choose Assign Macro, click on smarterSorting and click OK. Save the worksheet as an Excel Macro-Enabled Workbook (*.xlsm) file. You can now click on any shape to sort the table of data in order by that column's contents. Click a second time to reverse the sort order.

HOW IT WORKS

This line of code stores a value of 1 or 2 in a static variable called colSortOrder:

```
colSortOrder = (colSortOrder
Mod 2) + 1
```

This is used to toggle between sorting in ascending and descending order. The static variable remembers the last used sort order so that when you click a shape the second time in succession the sort order is reversed.

This statement uses the CurrentRegion property to dynamically select the data area starting in cell A1, however big the table is.

```
Set ourDataRange =
Range("A1").CurrentRegion
```

The Application.Caller property is used to return the address of the top left cell under the clicked shape and the macro uses that cell to identify the column to sort by. This lets us use a single macro for all the shapes.

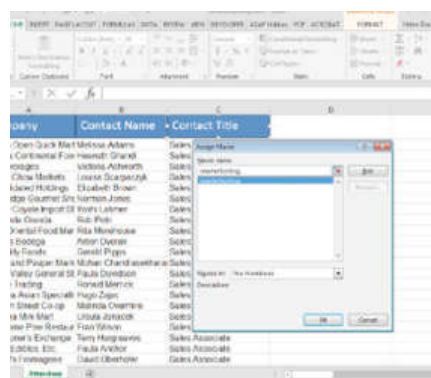Download the code for this Macro from **www.apcmag.com/magstuff**.
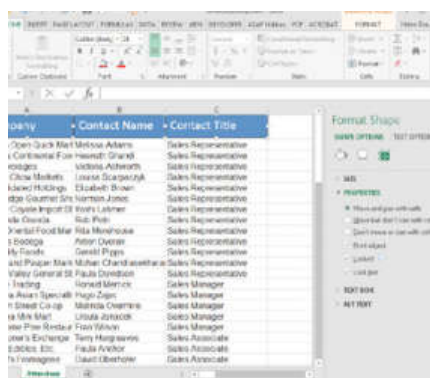
1 COVER UP
When you add a shape over a column heading, set its property to Move and Size with cells so it will adjust automatically to changes in column width or row height.
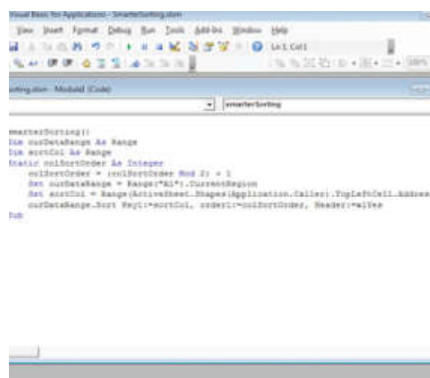
2 ASSIGN A MACRO
When you right-click a shape you can choose to assign a macro to it. This macro will run when the shape is clicked.
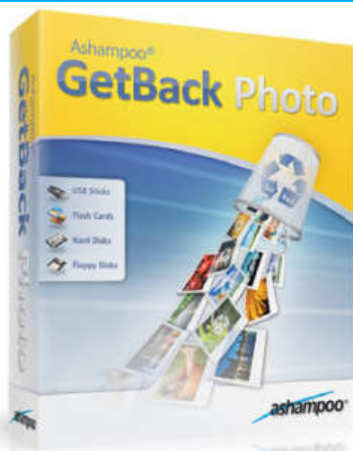

3 GET SORTED
The macro has been written so it can be used with every shape. Code in the macro determines the cell under the clicked shape so the data can be sorted by that column.

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ISSUE 421, NOVEMBER 2015

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NO DISC FOR NEW ZEALAND READERS?
Due to a New Zealand legal requirement that all physically-distributed video games (including indie titles and demos) be rated by the Classification board, we're sadly no longer able to offer our cover disc in New Zealand. However, so our loyal NZ readers don't miss out, we've created a special download page where you can access the exclusive software each month. You'll find it at **www.apcmag.com/exclusives**. While we've created this download page for New Zealand readers, it's also open to all of our Australian and tablet-edition readers too. All you need are the links and zip passwords printed above to be able to download and extract these exclusive full-version apps.

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SYSTEM REQUIREMENTS
- A DVD-ROM reader or burner.
- The *APC* disc is designed for use with up-to-date browsers (for example, Internet Explorer, Chrome, Firefox).
- The interface included on the *APC* disc requires a JavaScript-enabled browser.
- An internet connection may be required for online registration of software before use.
- The software packages on the *APC* disc have different system requirements. Software is included on the disc for Windows Vista, 7 and 8.

BEFORE INSTALLING
- Check the disc using a virus scanner complete with the latest antivirus data updates. The disc was checked before burning, but new viruses are being discovered all the time.
- Back up any important system and data files. It is not recommended that the software contained on these discs be installed on production machines.
- If you have any questions regarding the use of the *APC* disc, click the 'Help' button at the top of the screen.

USING THE DISC
- Insert the disc into a CD/DVD-ROM reader or burner and your web browser should automatically load the interface. If not, launch your web browser and load the default.html file from the root directory of the disc.

HELP
- If you have any problems with the *APC* disc, please visit **www.apcmag.com/disc.htm**.
- *APC* provides no technical support for this disc or any software provided on it.

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Create an easy Linux VPN

Neil Bothwick takes a break from configuring OpenVPN to show you an easy alternative for setting up a secure virtual network in minutes.

A VPN is considered the best option, if you want to connect to your network from the outside in a secure way. We've looked at setting up OpenVPN in the past, but it's not a trivial task. Both setting up the VPN server in the first place and managing changes when devices are added or moved can be time consuming. It would be great if someone were to give us an alternative that was easy to set up and manage, preferably with a simple web interface — well they have. ZeroTier provides a way to create a virtual network in less than a minute and add computers to it just as easily. ZeroTier uses a peer-to-peer protocol, where registration and device discovery goes through ZeroTier's central servers, and all other communication runs directly between the computers on your virtual network. Note: if both computers are on the same LAN the data doesn't go anywhere near the internet. Think of it like BitTorrent, where the tracker tells you who has the files you want, but the actual downloading and uploading goes nowhere near the tracker.

The first step is to install the ZeroTier software on your computer. You probably won't find it in your distribution's (distro) repositories (repos) as it's still rather new, but you can get various packages, as well as the source code, from the official website (**www.zerotier.com**). If there isn't a package for your distro, get the generic Linux installer and install with:

```
$ chmod +x
ZeroTierOneInstaller-
linux-x64-1_0_3
  $ ./ZeroTierOneInstaller-
linux-x64-1_0_3
```

CREATING A NETWORK

That's the current 64-bit version and the name may be slightly different when you try it. This provides the software to join a network, but first you need to create one. Go to **www.zerotier. com/admin/admin.html** and make an account which you'll need to create a network. If you want to join an existing network you can skip this section. Register your email address and a password and you'll be taken straight to the listing of your networks, which will be empty so type in a network name and press 'Create Network'. Your new network appears immediately on your admin page. The Network ID is a unique identifier for your network, you will need this to join the network. Other significant settings here are: Access Control, which you should leave on unless you want anyone to be able to join your network; and the IPv4 addressing setting, which you should change to have ZeroTier give each device an IP address when it joins. You will then be able to choose a block from which the addresses will be chosen. These addresses are only for your private network and won't be publicly accessible. It doesn't really matter which net block you choose, as long as it's not the same as any of the LANs you will be connecting to. Below this you will see a list of devices connected to the network, which is empty so let's add one.

The ZeroTier client for Linux is command line only, but before we can use it the zerotier-one service must be running. SysVInit and Systemd startup files are provided, Systemd users can start it with `$ sudo systemctl start zerotier-one.service`. You should set your computer to start the ZeroTier service when it boots if you want your network to be always available. Now open a terminal and run: `$ sudo zerotier-cli join <NETWORKID>`. Now refresh the web page, or wait a few seconds, and you will see an entry under devices. However, if you run: `$ sudo zerotier-cli listnetworks`. In your terminal, you will see this network shown as access denied. This is part of the security of ZeroTier: a user can't join your network without your say so. Go back to the web page and tick the 'Authorize' box. After a short while the page will update to show an IP address for this device, and `zerotier-cli listnetworks` will show the same.

Although you gave your network a name, this is only for your convenience as ZeroTier uses IDs to identify networks and devices. Network IDs are the 16-character strings we have already used to add a device to a network. Device IDs are 10 characters and can be seen on the device list and also in the output from `$ zerotier-cli info`, which also shows your online status and the version of the software you are running. So far, we have had to run `zerotier-cli` with `sudo` or as root. It's possible to authorise specific users to use ZeroTier by running this command as the user you want to authorise:

```
  $ sudo cat /var/lib/zerotier-
one/authtoken.secret >~/.
zeroTierOneAuthToken
```

To do it for a user without `sudo` permissions, copy the `authtoken. secret` file as above and use `chown` to have to owned by that user.

MANAGING ADDRESSES

Going back to the admin web page you

Keep it in-house

At this point, you may be wondering about ZeroTier's servers — are there any disadvantages to using a system that has a public discovery server? While its servers could be compromised, the code is visible, which means it's up to you to decide how much you trust it.

The service is free, but limited to ten computers per network, although it appears you can create as many networks as you want. If you want more than ten users on a network, you can pay $4 per month or you can run your own server, which also means you have full control over your data.

The binary packages don't include the server, so download and unpack the source and run:

```
$ make ZT_ENABLE_NETWORK_CONTROLLER=1
installer
```

This compiles the zerotier-one program with network controller support and then goes on to build an installer package that you simply need to run, as you would do with the downloadable installer. Now you can run:

```
$ /var/lib/zerotier-one/zerotier-one -d
```

This starts the network controller. It listens on UDP port 9993, so make sure your router forwards that to the computer running as a controller. Read the service/README.md file in the source tree for details of running your own controller. This does defeat some of the advantages of ZeroTier and it puts more of the work back onto you, but for a largish network, or where utmost security is important, it may still be an alternative to self-hosted OpenVPN.

---

will see that your device has been allocated an IP address within the block you choose. If you wish to use a different address, I use the same final number as the LAN address for each device for convenience, click on it to add a new address and delete the old one. You can also give each device a name, but this is simply a label to help you identify the devices not a hostname. If you want to be able to access your computers by name rather than address, you will need to add a line to `/etc/hosts` for each one, like this

```
192.168.241.231        desktop
192.168.241.90         laptop
```

All traffic on your virtual network takes the shortest route. If you plug your laptop into your LAN you can continue to use the ZeroTier addresses for it and your other computers and the traffic will stay entirely on your LAN. This means you don't have the hassle of starting and stopping a VPN connection depending on where you are as you can just leave it running all the time. If you don't have an internet connection, the ZeroTier interface will wait until it's able to connect. There may be a slight performance hit with a slower computer when using a ZeroTier connection over your LAN, compared with a direct connection, because ZeroTier encrypts all traffic.

Clearly, there are security considerations when allowing access to your private network from outside. ZeroTier is open source, which is especially important for cryptographic software as you need to be sure that the algorithms and code are secure — security is provided by a strong key not by obscuring the code and ZeroTier uses 256-bit encryption. You don't want anyone joining your private network (you would have unticked the private box otherwise) but the join and authorise mechanism mean that no one can connect their device to your network without access to your admin

page, and you can't connect someone else's device to your network without access to that device. You need access to both ends to set up the connection.

It goes without saying that you should use a strong, preferably randomly generated, password for your ZeroTier account. ◾

The ZeroTier admin page, where you manage your networks. Note the handy help at the side.

The zerotier-cli command is simple to use with only a few commands. Apart from joining and leaving networks, you will hardly need to use it.

Linux file-sharing made easy

Neil Bothwick lays down a selection of quick and easy ways to share files and the contents of folders without network filesystems or cloud storage.

When we speak of file sharing, thoughts probably turn to network filesystems, such as NFS and *Samba*, or cloud storage services like Dropbox or SpiderOak. However, sometimes you just need to get a file from one computer to another with the minimum of fuss – something that configuring Samba doesn't qualify for. Why not use a cloud service? They can be the simplest option, assuming you already have an account, but they have their own limitations. Some have limits on the size of individual files, or their mobile clients lack upload capabilities, and there are the inevitable privacy issues. They are also unsuitable for sharing larger files over a local network as everything has to be uploaded to their servers and then downloaded. You could use OwnCloud (**owncloud.org**) for a local cloud service, but once again we are into the realms of significant setup effort.

There are plenty of other options. You could use the ol' Sneakernet and copy the files to a USB stick and then walk to the other computer to read them, but we'll stick to networked solutions here. All of these are simple to set up and require a minimum of software to be installed on your computer, if any at all in some cases. They are also simple for other users, often requiring only a browser, so you can share files with the less geeky members of your family.

If you just want to share a single directory over the local network, you can do this with Python, which you already have installed. All you need to do is open a terminal, `cd` to the directory containing the files you want to share and run:

```
$ python -m SimpleHTTPServer 1111
```

The number, 1111 here, is the port you want to listen on. For a user process, it must be higher than 1024, and obviously not in use by anything else. The command is case sensitive. Now give your IP address and the port number to anyone you want to share with and they can access the files in that directory by pointing their browser at **http://your.ip.address:1111**. Note: There's no security here and anyone on your local network can access any file in that directory. To stop the server at any time by pressing Ctrl-C in the terminal.

SHARE ONE FILE ONCE

Running a web server is fine if you want to give everyone unlimited access to a directory, but what if you just want to share a single file? Woof (Web Offer One File) does just that. It is a Python script available from **www.home. unix-ag.org/simon/woof.html** – download it, make it executable and put it in your path, then you can share a single file with this command:

```
$ woof /path/to/myfile
```

It prints a URL that you can send to the recipient. The recipient needs no special software, they can just click on the URL to download the file. What makes woof different is that, as well as only allowing a single file download and no directory browsing, it exits as soon as the file has been downloaded once. There's no web server hanging around offering access to your computer long after it is needed. You can have it allow multiple downloads with the `-c` option as well as specify the address and port instead of letting woof choose them. Choosing a specific port is important if you need to forward it from your router. Another neat feature is that you can pass it a directory instead of a file. It doesn't allow browsing of the directory, instead it serves a tarball of the directory's content. You can even share your copy of woof with:

```
$ woof -s
```

Another option is *pshs* (**http://bit.ly/UsePSHS**). This requires compiling and installing in the usual way:
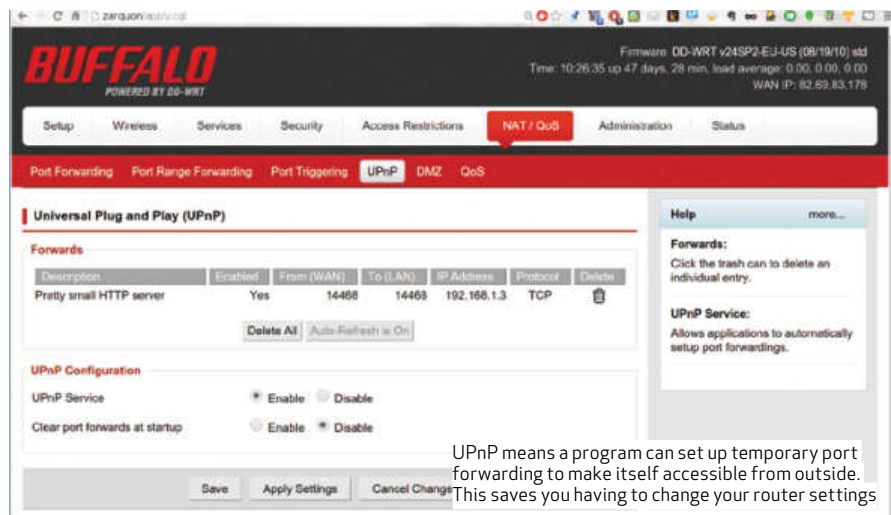
```
$ tar xf pshs-0.2.6.tar.bz2
$ cd pshs-0.2.6
$ ./configure && make && sudo make install
```

And run it like this:

```
$ pshs file1 file2 ...
```

What this does is print a URL that you can use to access all the files in the list. It looks like a directory listing, but it's just a list of the given files, there is no other filesystem access. There are a couple of differences you may notice. The first is that in addition to the URL for the files, *pshs* prints a QR code to the terminal, which you can use to share the files' URL. You may also notice a slight delay before you see the

UPnP means a program can set up temporary port forwarding to make itself accessible from outside. This saves you having to change your router settings

Connecting from outside

The methods we have described here are fine if you are working on a trusted local network, but what if you want to share files with external devices? You can forward ports on your router to your computer to allow connections to come through, and pshs can do this automatically with UPnP, but then anyone out there can see your files. The risk is low as you are only serving specific files, and even lower with woof as it will terminate and close the port once the file has been downloaded, but there may be hidden security exploits, as with any software. Leaving the port forwarded while the program isn't running is fine, if there is nothing listening, there is nothing to be hacked.

The safest option is to use SSH in one way or another. You can use the SFTP option, which is secure but not as simple to use. If you want to share files with less savvy users for whom the internet lives in a web browser, use one of the programs covered here, but use SSH yourself to start and stop it so that it is only running when needed. If you want to serve files continuously, you should be looking at something like OwnCloud rather than these quick, ad hoc methods we've discussed.

A final option, for maximum security, is to use a Virtual Private Network (VPN) so all files are effectively shared over your own network, but that's a topic for another article.

URL and QR code. This is the program querying your router to set up access from outside via UPnP. This requires a UPnP-enabled router but means you can share files outside of your local network without messing around with port forwarding. If you don't want the external access, just add `--no-upnp` or `-U` option to disable it. Currently, *pshs* only supports sharing files and not directories, although you can use shell wildcards to share the contents of a directory, or even use find to share all files in a directory tree:
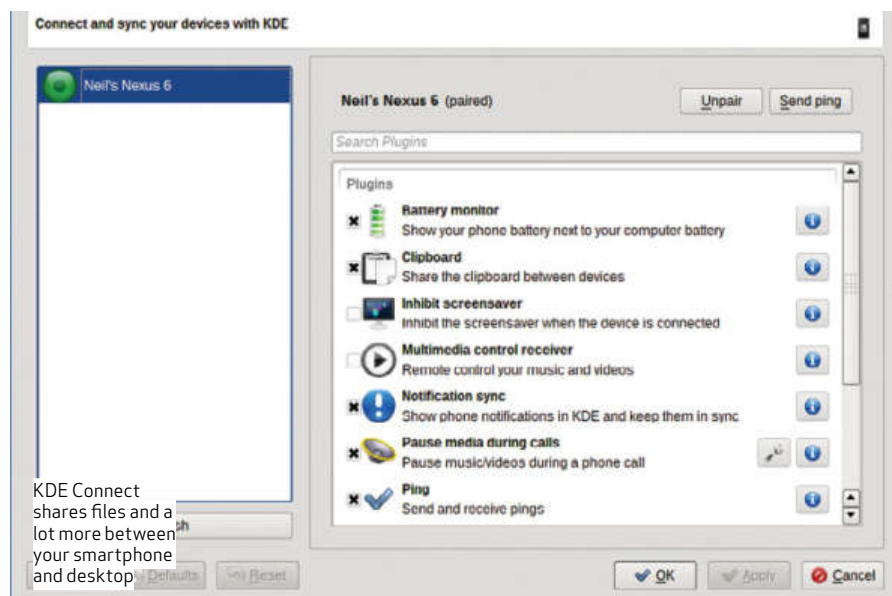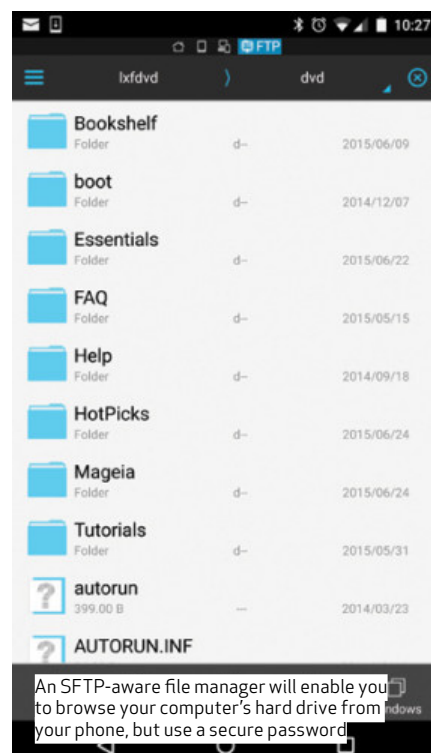
```
$ pshs dir1/*
$ pshs $(find dir2 -type f)
```

There is also an option to use SSL for the transfer, add `--ssl` to the command. This uses a self-generated certificate, so your browser will give you dire warnings about it being an untrusted connection, but it will mean your traffic is encrypted.

SHARING WITH YOUR PHONE

If you want to share a file from your computer to your phone, any of the previously mentioned methods will work. The simplest is *pshs* because it prints a QR code that you can scan with your phone's camera. There are several ways of sharing in the other direction. If you are running an SSH server on your computer, you can use one of the many Android file managers that support SFTP, I use ES File Manager that (**www.estrongs.com**) allows me to access my desktop's files using SFTP (a subset of SSH). While you can use SSH keys for the most convenient of connections, this may not be such a good idea on a device that's easily lost or stolen, you would effectively be leaving your entire desktop hard drive up for grabs. So use a decent SSH password. If you are running an outward-facing SSH server, it's probably also a good idea to run it on a non-standard port to stop your connection being hammered by script kiddies. Neither of these apply if you only have SSH available on your LAN.

There are Android apps that make sharing files easy, the most compete of which is KDE Connect (**community.kde.org/KDEConnect**). As you may have guessed this uses the KDE desktop, but it's possible to use it with other

An SFTP-aware file manager will enable you to browse your computer's hard drive from your phone, but use a secure password

KDE Connect shares files and a lot more between your smartphone and desktop

desktops. After installing the apps on both computer and phone, you pair them while both are connected to the same network (KDE Connect only works over Wi-Fi). The standard Android Share menu will then contain an option for KDE Connect that copies the file to a folder on your computer. There's also a remote filesystem browser option at the computer end that allows you to browse the phone's filesystem as well as upload and download files. KDE Connect has some other neat features, like phone notifications and low battery warnings on your desktop.

If you aren't using KDE, you can still try KDE Connect (there's also a command-line client that's useful for scripting or backups) or try DeskCon (**http://bit.ly/DeskCon**) or LinConnect (**http://bit.ly/LinConnect**). They aren't as full-featured as KDE Connect but they are more cross-desktop. ∎
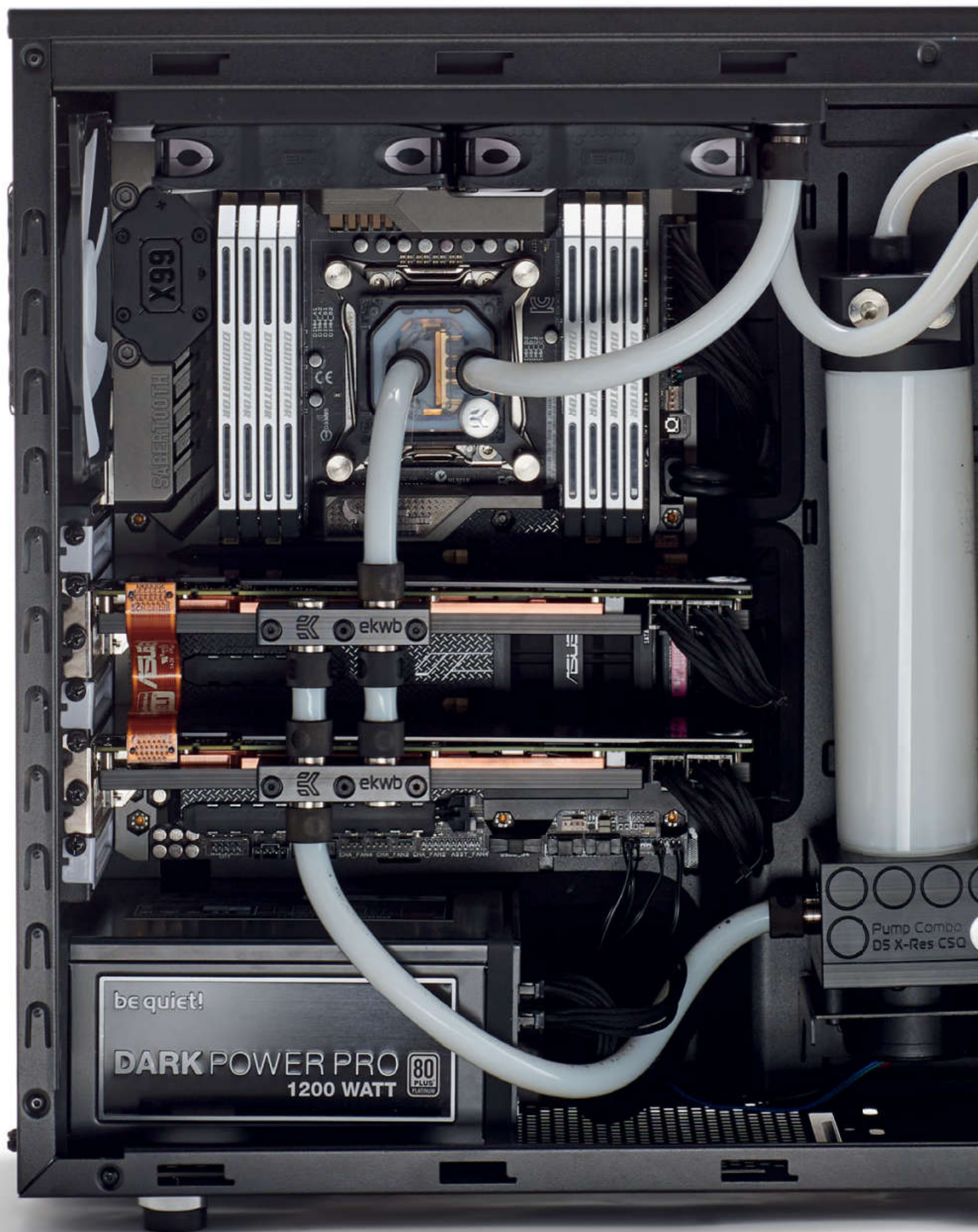
Special guide: Water Cooling 101

Want to become a water-cooling master? Zak Storey reveals the how, what and why of it.

For much of recent history, water cooling has been shunned. Only a select few could afford to merrily dance with computing death, taking their chances with water-cooling hardware and components that weren't even designed to work in the silicon environment. They'd ghetto-graft G1/4-inch plumbing fittings onto hardware and hand-mill various water blocks, all in the hope of creating a leak-proof, watertight system. A system that could efficiently and effectively transfer heat away from their component parts, to a far greater degree than traditional air coolers ever could.

It was back in the noughties, a time when the average PC enthusiast was less concerned about how a PC looked.

More important was how many frames per second they could squeeze from their beige box of dominance in Unreal Tournament. It was a terrifying time. But over the last five years, the situation has changed dramatically.

Water-cooling manufacturers and modding companies — such as EKWB, XSPC, Primochill, Bitspower and E22 — have come to the forefront in far greater numbers. This is when and why water cooling really began to take centre stage. Indeed, today you'd be hard-pressed to find a high-end system that's not running some form of all-in-one CPU cooler or a custom loop. Hell, all of us here at the *APC* office would run hard-piped builds if we could, and there isn't one of us still stuck on the retail cooler, or even an air cooler for that matter.

So, what is it that attracts people to water cooling? Why is it so much better than traditional air cooling? Essentially, all forms of cooling work on the same basic principles. You might have heard of them, they're part of the laws of thermal and fluid dynamics. No matter whether you have an air cooler or a full custom-loop setup, you're transferring heat using water from one point to the other. It then cools and circulates back around again to transfer that heat out of the system and to the outside environment again and again.

All very fancy, right? Air cooling technically isn't an accurate description of that cooling method, and neither is water cooling — they both essentially require a fan and a radiator to exhaust that heat. So, is water cooling for you? Should you dive into the murky depths of H2O nirvana? Maybe you'll discover something about yourself along the way… Read on to find out.

WHY WATER COOL?

Let's cut straight to it. Primarily, water cooling is done to enhance the aesthetic beauty of a build. Don't get us wrong, the heat-reducing properties of multiple radiators and fans cooling your internal components is fantastic and highly efficient. But if you're looking for the most effective price-to-performance ratios, a good AIO cooler for your CPU and a triple fan-designed GPU would be more than enough to ensure you never hit any of the thermal limits dictated to us by our silicon-inducing overlords. And in today's technological climate, you're far more likely to encounter hardware-based limits, rather than temperature-based ones, in your overclock attempts.

One of the biggest benefits of water cooling, besides looking better than Gabe Newell's monthly bank statements, is the noise reduction. Simply put, noise control is all about effective fan control. It's not necessarily how many fans you have,
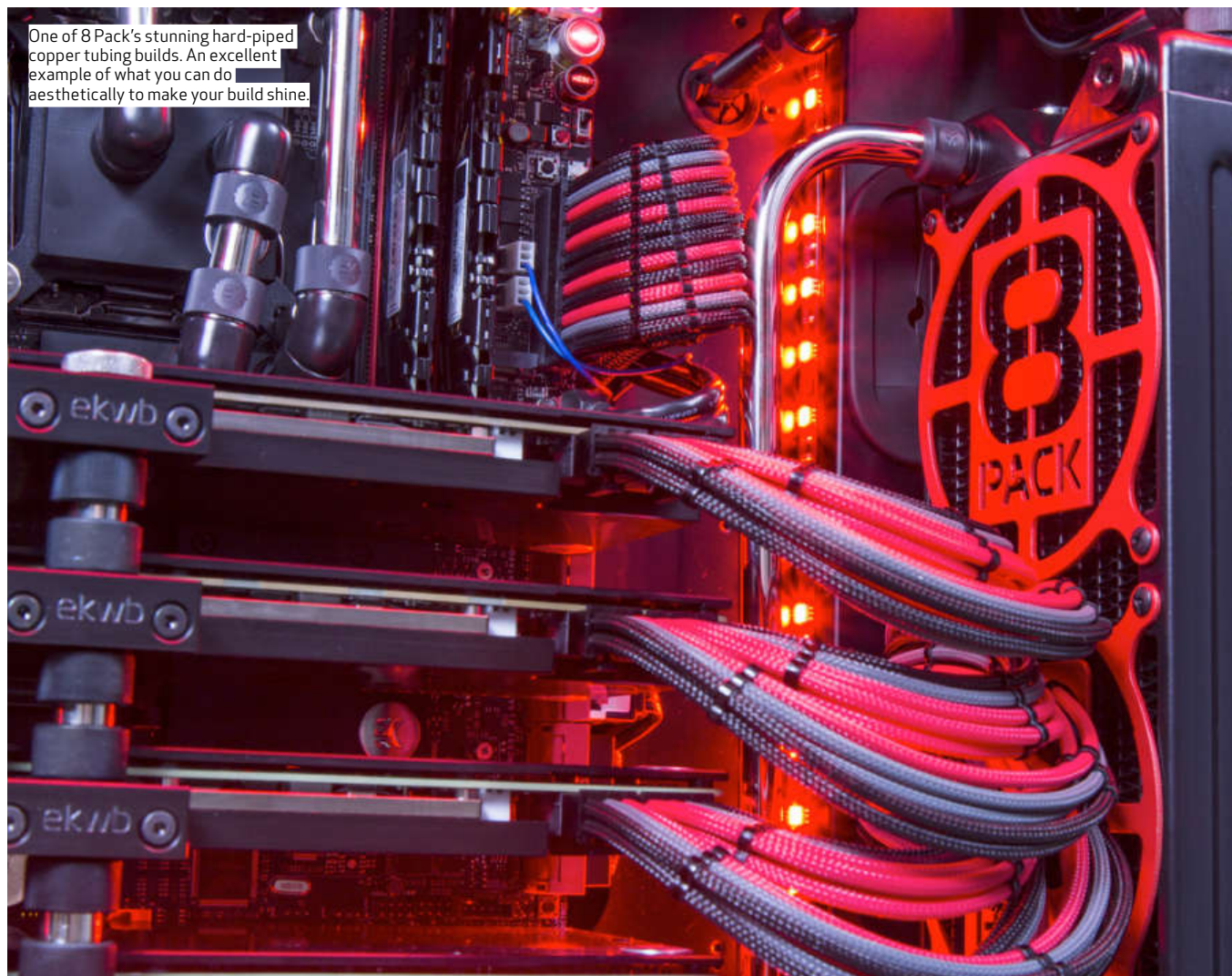
One of 8 Pack's stunning hard-piped copper tubing builds. An excellent example of what you can do aesthetically to make your build shine.

"One of the benefits of water cooling is noise reduction."

but how fast they're spinning. Ultimately, the lower the RPM, the lower the noise output. For instance, if you take five 120mm fans and run them at 1,200rpm, and then take two separate 120mm fans and run them at 3,000rpm, we can guarantee the two fans will be creating more audible noise than the five.

AESTHETICS
Water cooling is primarily about enhancing the look of your build, ensuring your silicon shrapnel stands out from the crowd and looks as good as it possibly can. There are multiple ways of doing this with water cooling. By all means, we're not saying that air-cooled builds can't look good — there are some seriously stunning rigs out there that run on simple old air coolers. But water cooling sits at the centre of the modding community. It's responsible for most of the innovations

we've seen in this area of the market. Whether that's braided cables, windowed-side panels or LED lighting, you can assume that the vast majority of these ideas originated from some modder out there ghettoing an idea onto one of their builds, and then showing it off to the masses.

So, you have four options in total when it comes to liquefying your machine. First, you could simply just use an AIO cooler. This way, you avoid the hassle of setting up any kind of crazy system, you're covered by a warranty and still gain the benefits of having a water-cooled CPU. Your second option is to go with a soft tubing loop, utilising flexible coloured or clear tubing. This is one of the most adaptable water-cooling methods as the tubing is flexible and easy to use.

The third and currently most popular option is to use acrylic tubing, most notably PETG tubing. This

non-fragile, highly robust hard piping creates an entirely different look for a build, utilising straight lines and angles to really make your rig pop. And then, finally, there's copper tubing. It's identical in almost every way to acrylic tubing, except it's far easier to bend and a lot cheaper, too. Copper provides a good base to either nickel or chrome plate or even powder coat as well, though it's opaque. Whichever way you choose, you'll still benefit from the reduced noise and the far-superior cooling capacity that water cooling provides.

WATER-COOLING COMPONENTS
If you thought that building a custom PC was tricky enough, then we've got some bad news for you. Here's a quick rundown of what you'll have to consider purchasing on top of your standard build. You'll need: A case, tubing, radiator(s), a CPU block, GPU block(s), GPU backplate(s), memory block(s), reservoir(s), pump(s), compression fittings, angled fittings, bulkhead fittings, stop valves, coolant and fans. Once you've decided how you want to cool your rig and what chassis

EK's Supremacy Evo CPU block provides incredible cooling with a simple mounting mechanism. We went transparent to show off our snazzy white pastel coolant.

you want to cool your build in, then it's a simple matter of pricing the lot up, throwing it all in the basket and breaking your wallet in two as you fork out for an expensive exercise in PC modding.

CPU BLOCK
By far the most obvious component to cool your rig. You'll need to make sure you buy a CPU block that's compatible with the chip you're trying to cool. More often than not, this is just a simple difference between Intel and AMD, as the processors don't tend to vary greatly in size.

GPU BLOCK
Predictably, GPUs experience the greatest deal of variance. Both in the design of the PCB and in which graphics processor you choose as well. You'll need to make sure you buy a compatible block for your card. Some manufacturers, such as EKWB, will often include specific water blocks designed to work with aftermarket cards such as Gigabyte's Windforce, MSI's Lightning or the ASUS STRIX series of cards. This may extend as far as the backplate as well, so always double check.

MEMORY BLOCK
Whether or not you decide to cool the RAM with your custom loop is entirely up to you. They certainly do output heat. But really, it just looks more awesome than anything else. Besides, nobody will penalise you if all you're looking for is to cool your CPU and GPU. You'll also need compatible RAM modules that match up with your water blocks.

FITTINGS
The most important parts of your build are the fittings you choose to use. Depending on what tubing you decide upon, you'll need either compression fittings or acrylic fittings. Although acrylic fittings are still technically compression fittings, they're designed to work around hard tubing by not crushing the acrylic as much, unlike traditional compression fittings, which tend to have a greater pinch to them. If you're looking for a basic build, you can usually get away with just the standard fittings.

However, if you're looking at designing a build with cleaner lines and a little more flare, you may want to invest in some angled fittings as well, usually stipulated at 45 or 90 degrees. Additionally, a stop

Dispelling the myths
Many fictions cloud the world of water cooling, so we've sifted the reality from the rumour.

MYTH 1
If I use deionised water in my loop, then leaks won't matter or cause any damage.

Unfortunately, no. As soon as the water is introduced to the system, it will begin making contact with the various metals inside of the water blocks. It will soon be picking up positive ions, meaning it'll be conductive within a couple of hours, at the very least.

MYTH 2
What If I blow it up when I switch it on? What if there's an instant leak?

Honestly, you're seriously not going to damage anything. The best way to fill and test a loop is to make sure everything's unpowered by using a PSU bridge. By using this bridge, you can switch on just the pump and that's it. Leave this on for 24–48 hours to see if you have any leaks.

MYTH 3
If I water cool my PC and add more fans, it's going to cool down my room right?

Definitely not. In fact, it's more than likely that the opposite will occur. Your hardware may run cooler, but you'll still be outputting the same amount of heat (or maybe even more if you're ramping up that overclock higher), out of the same radiators. If anything, your room will become warmer as you'll have more fans pushing more heat out of those radiators.
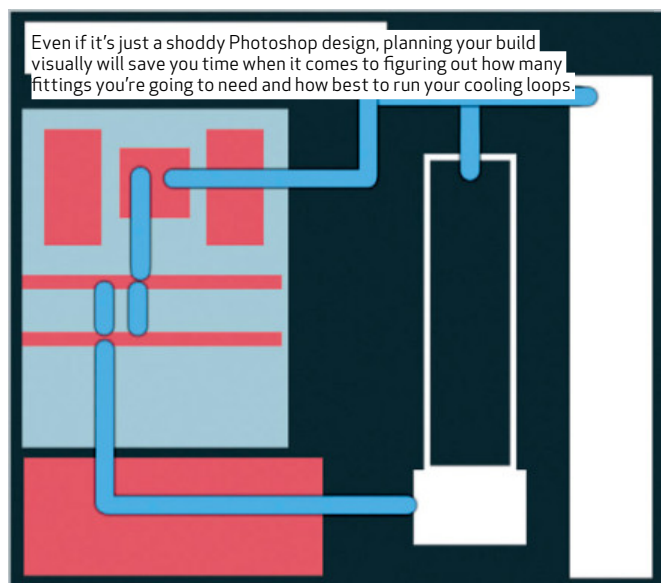
Even if it's just a shoddy Photoshop design, planning your build visually will save you time when it comes to figuring out how many fittings you're going to need and how best to run your cooling loops.

Making sure you've got enough space to work inside of your chassis is vital for having a stress-free, easy build.

valve might come in handy for loop maintenance.

PUMP / RESERVOIRS

Technically, you don't need to buy a reservoir to successfully run a water-cooled loop. However, they do look rather impressive, and make it a lot easier to fill a water-cooled system than using other methods. You will, however, always need a pump to ensure that the fluid within your system is flowing, and pulling heat away from your core components and out to the radiators. Additionally, you should always have your pump gravity fed (meaning fluid should always be flowing down into it).

RADIATORS AND STATIC PRESSURE

At this point, you need to be looking at how you're going to output that heat. The only option you have is to use radiators. You can do this however you like, either by utilising separate loops for your GPUs and CPUs or by combining the two together into one single loop. But you'll still need radiators to get rid of all of that heat, and accompanying fans to reduce this per loop.

Once you've decided what space your case has for radiators and how many you're going to use, you need to take a closer look at the FPI and thickness of the radiators you'll be using. FPI stands for fins per inch. Essentially, the higher the FPI, the higher the static pressure you're going to need to effectively move cool air through that radiator. For instance, if you have a radiator with an FPI of 38, you'll probably want static pressure-optimised fans. However, if you have deeper radiators with a lower FPI of 16, you won't see any comparable difference between static pressure fans or airflow fans. In fact, in these cases, you're often better

off equipping them with airflow fans instead.

WHERE TO BUY?

There isn't a fantastic array of places where you can buy a lot of these components in Australia. But a good place to start looking for good deals is **www.staticice.com.au**. Additionally, if you're a little more patient and want to ensure you're getting kit directly from the source, you can often buy straight from vendor's sites, such as EKWB (**www. ekwb.com**). EKWB was instrumental in providing us with the hardware for this feature, and ships internationally.

PLANNING YOUR LOOP

So, at this point, you should be well aware of all the hardware you'll need to be looking at. Next, you want to research which case is best. There's a huge variety out there. In fact, you'll find there'll be water-cooling cases from Mini-ITX chassis all the way up to full E-ATX super towers. Once you've found your case, check what radiators it can support for water cooling. Then you need to think about your tubing and how you're going to cool it — a single loop or dual loops. Once you have all these facts nailed down, your best bet is to sketch out how you want to run your loop, and how many fittings you'll need for all your hardware. Usually, you'll need two fittings per water cooling item — an in and an out.

For us, the choice was pretty simple. We'd use the Fractal Define S, a case designed from the ground up for easy water-cooling installation. A dual radiator at the top and a triple rad at the front. On top of this, we'd be using a single closed loop to cool both of the EVGA Superclocked GTX 980 Ti's and the Intel Core i7-5820K. Then it was a matter of tallying up how many


fittings we needed, taking into account we'd be using soft tubing and a pump/res combo, as well as planning how our build would look. We'd be using an ASUS X99 Sabertooth TUF motherboard — stunningly gorgeous and covered in black and grey-plated armour. On top of this, we managed to get a hold of a mixture of black water blocks and fittings. We'd use white coolant to add a little contrast.

CHOOSING THE CHASSIS

Picking the right case can be a tricky business, especially when you're looking to do a water-cooled mod such as this. The best way to do this is to look out for cases designed particularly for water cooling, or by companies who revolve around it. Parvum, Phanteks, Corsair, Caselabs and Fractal are all fantastic case firms that provide some excellent rigs to work and build in, making it easy to
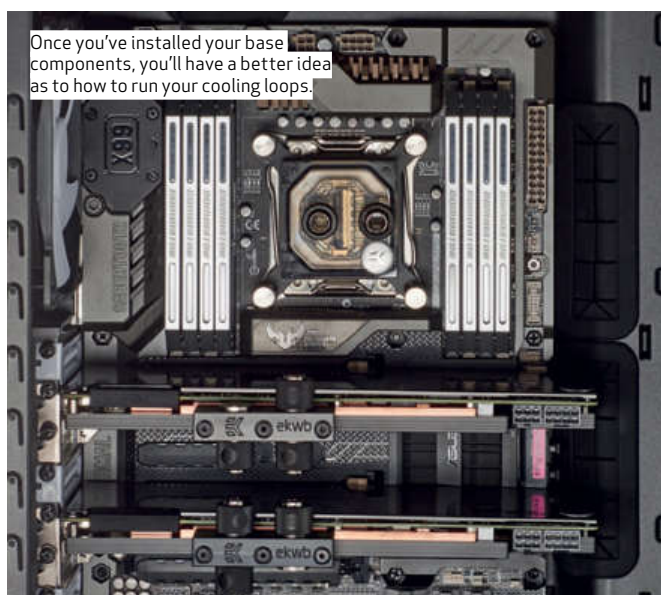
Once you've installed your base components, you'll have a better idea as to how to run your cooling loops.
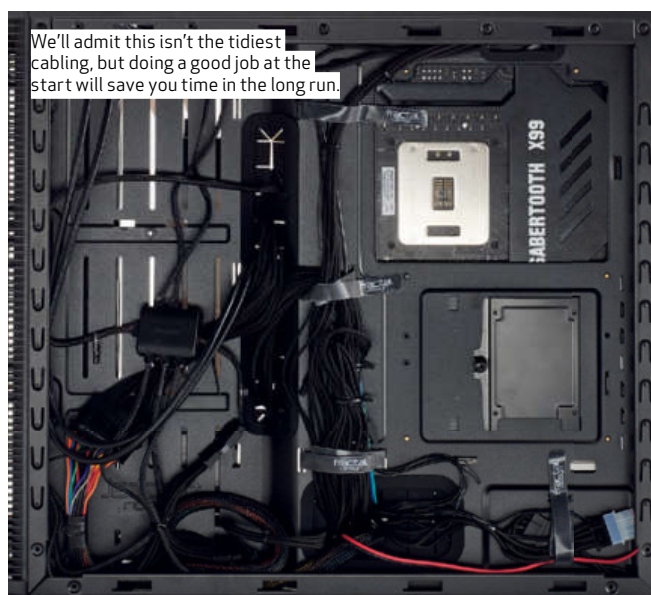
We'll admit this isn't the tidiest cabling, but doing a good job at the start will save you time in the long run.

create a stunning work of art.

Selecting the right case is undoubtedly the biggest consideration you have to make. It will dictate where your reservoir goes, how many radiators fit and what thickness they are, plus how your tubing runs will work. For instance, we tried to build this particular setup inside of the Phanteks Enthoo Evolv, but we'd already pre-ordered the water-cooling components for a different chassis and they ended up being incompatible with the Phanteks, even though that's a huge case to work in.

FITTINGS AND LOOPS

And so begins the building process. Of course, like with our regular builds, we generally advise that you build all your PCs outside of the case first, just to see if they work at stock. We individually tested both our GPUs, the memory and the CPU with traditional coolers, before throwing water blocks on any of it.

Then we began the internal build process, stripping the chassis of any unwanted components, such as hard drive bays and cages, and continued to install the motherboard, the memory and the GPUs, securing them firmly to ensure that nothing would fall out or become damaged over the course of our build. We also took this opportunity to install the radiators and plug in the fans where they were necessary. It's also time to attach the reservoir, and install all of the fittings.

"If you're looking for more flare, invest in angled fittings."

CABLE MANAGEMENT

In a build like this, cable management needs to be flawless. The last thing you want is excess, untidy cables cluttering up your rig. Not only will they get in the way of the tubing, they'll also restrict airflow and generally make your tubing routes that little bit more difficult. Cablemod (**www.cablemod. com**) provides custom-sleeved cables for Be Quiet!, Cooler Master, Corsair, EVGA and Seasonic power supplies. These should spruce up your build quite nicely. Alternatively, it's not impossible to sleeve the cables yourself. This takes a lot more time and patience, but you can include cable combs to keep the cables tidy, plus vary your colour schemes.

Additionally, we used the Phanteks PWM Fan Hub. Threading all five Noiseblocker fans through one fan

controller means we can control how much power they receive directly from the CPU fan header, meaning the system will ramp up or down, dependent on CPU temperature (which admittedly will be quite low for this build).

BUILDING AND PRIMING THE LOOP

At this point, it's time to start your tubing runs. Line up a stretch of tubing between the two points you wish to connect, then cut a little more off than you think you'll need. It's better to have too much than too little — you can always shorten the runs later. Next, unscrew one of the fittings, wiggle your tubing onto the fitting and thread the other end of the compression fitting onto the unattached end. Then screw it down, compressing the tubing in place.

If you're struggling to fit the tubing on, use a pair of needle-nose pliers. Gently insert them into the end of the tubing and carefully stretch the tubing slightly, so it's easier to work. Then you'll need to take the sleeve off the other fitting, pre-attach that to your new tube and do the same with the other end. It's then simply a case of running all of the tubes to their correct lines. It doesn't matter which tube goes where, as long as it creates a loop. Once the system is sealed off and pressurised, the temperature of the water will be consistent around the entirety of the loop, regardless of which component goes to which first. Thanks science!

You're now at the scary part —

It will take time to get your loops right (it took us three attempts to master the bridge between our GPUs). But once it feels snug and secure, you can smash on and start filling your loop. Always throw paper towels underneath everything — they're a good early indicator of a leak.

priming your loop. Ensuring that the reservoir is gravity feeding the pump (in other words, it's above), attach one last fitting with a length of tubing onto the top of the reservoir (depending on how you have your reservoir set up, it might be advisable to get a multi-port top adaptor). Then use a funnel to carefully pour your coolant into the loop. In our case, we like to just use a squirty plastic sauce bottle to fill our loop.

Before doing any of this, you want to make sure that everything on your motherboard is unpowered. Ensure that your CPU power, your motherboard ATX power and any power cables heading to your graphics card are all unplugged, either at the power supply end or the hardware's end. Then you'll want to either bridge the two power points on the ATX power with a paper clip, or use a specially designed bridge connector. Then it's simply a case of switching the power on every time you fill the reservoir, until the entire loop is filled. Just remember not to do this until after your reservoir/pump has fluid inside of it.

SPECIFICATIONS

CPU	INTEL CORE I7-5820K @ 4.4GHZ
MOTHERBOARD	ASUS SABERTOOTH X99
MEMORY	64GB CORSAIR DOMINATOR PLATINUM (8X 8GB) @ 2,666MHZ
GRAPHICS	2X EVGA GEFORCE GTX 980 TI SUPERCLOCKED ACX 2.0+
STORAGE	2X SAMSUNG 850 EVO 500GB SSD
CASE	FRACTAL DEFINE S
POWER SUPPLY	BE QUIET DARK POWER PRO 11 1,200W – PLATINUM
FANS	5X NOISE BLOCKER NB-ELOOP B12-2 120MM FANS

CONCLUSION

As you've probably already spotted, the build looks great. Matching the black EK water blocks with the ASUS X99 TUF Sabertooth worked out really well, and the white provides a brilliant contrast to the overall style and look.

The temperatures are where we expected them to be. We clocked the Core i7-5820K up to 4.4GHz and recorded temperatures at 55°C under load. The GPUs remained at around 60 degrees under full load and we maintained the fans at a constant 20% speed throughout the system. For performance, we couldn't really get much more out of either the GPUs or the CPU as they were already at their hardware limits. But either way, the performance was still outstanding, and the fact that it remained so quiet even while under high load is really something else.

A worthy mention here is definitely the coolant. We used EK White Pastel coolant to fill our loop and it looks fantastic, even with a soft tubing loop. Our leak test went without a hitch. Although we could only test it for around 45 minutes during the shoot, there was absolutely no spillage. The EK compression fittings ensured an incredibly tight seal around all of the components. That is, as long as you haven't damaged the tubing in the process (especially if you're lazy like us and use scissors). Generally speaking, you should always run a leak test for 24 hours minimum before powering any of the components on, but in our case, we simply didn't have time.

In hindsight, we'd have loved to have gone with hard tubing. It's all the rage at the moment, and rightly so — it's some of the nicest-looking water-cooled work you can do. A larger case would have also been good. One of Caselabs's Magnum SM8s or Parvum's ATX chassis would've been fab — going up to two 360mm radiators instead of just the one and a dual radiator would have been great for additional cooling.

A different chip would have also been nice, just to see if we could push beyond the silicon limits on ours. Thermally, there's no issue with our 5820K, it just won't clock beyond 4.4GHz, but that could have been a different story if we'd gone beyond the 4.7GHz boundary. Additionally, running two loops would've looked stunning. One in black and one in white, separating the GPU and the CPU.

Should you be water cooling, though? That was the original question. It depends on your budget. As with any build, hard cash is ultimately what it always comes down to. If you're looking for the best bang for your buck, water cooling with a custom loop just isn't for you. Even if you do it on the relative cheap, you'll still be looking at somewhere around the region of $800, minimum, on top of everything else.

Water cooling is for those looking to build a beautiful and quiet workstation capable of destroying benchmarks and running any task you can throw at it with absolute silent ease. It's not for the faint hearted, and although water cooling has come a long way since the first attempts way back yonder, it's still filled with danger and possible hardware failure. But then, we don't know of any aspect of the PC enthusiast's arsenal that isn't. ▪

DIY cloud with a Raspberry Pi 2

OwnCloud is one of the best pieces of open-source software to help you create your own private and protected cloud-sharing service. Mayank Sharma shows you how to use it.

Using OwnCloud, you can sync and share your private data, and access it from any device connected to the internet. For added security, OwnCloud can also encrypt your files. The software can handle files in a variety of formats and you can extend its usability by adding a number of other apps. As with other online cloud storage services, you can sync files on OwnCloud either using the web browser or a desktop client on Windows, Mac and Linux, as well as mobile clients for Android and iOS devices. Furthermore, your OwnCloud server keeps older versions of all changed files and enables you to revert to an older version without much effort.

1 LAY THE GROUNDWORK

In this tutorial, we're setting up the OwnCloud server on top of the Raspbian distribution for the Raspberry Pi [Image A]. The server software has modest requirements and it performs well, even on the Raspberry Pi Model B, in certain small and controlled environments, such as your house. You also need a USB portable disk for storing the data. For maximum reliability and performance, it's best to use a self-powered disk that doesn't draw power from the Raspberry Pi. Before you begin setting up the server, make sure the Raspberry Pi has a static IP address. The easiest way to do this is to tie an IP address to your Pi's unique MAC address in your router's admin page. Here, we're assuming the Pi is at 192.168.3.111 — change as appropriate.

2 INSTALL OWNCLOUD

Raspbian is based on the Debian OS, so we can pull in packages from OwnCloud's Debian repository. Fire up a terminal and add the OwnCloud repositories with:

```
$ wget http://download.
opensuse.org/repositories/
isv:OwnCloud:community/
Debian_7.0/Release.key $ sudo
apt-key add - < Release.key
```

You can now refresh the repositories with:

```
$ sudo apt-get update
```

Now install the OwnCloud server and all its required dependencies as follows:

```
$ sudo apt-get install
owncloud.
```

This also pulls in and sets up the MySQL database, and you're asked to set up a root password.

In addition to installing the required components, the above command automatically configures the Apache web server to talk to the OwnCloud installation. You need to enable certain Apache modules. In a terminal, enter:

```
$ sudo a2enmod headers
rewrite env
```

Then restart Apache using:

```
$ sudo apachectl restart.
```

You have to tweak the configuration file of PHP if you wish to upload files that are greater than 2MB in size. To do that, open the PHP configuration file, 'php.ini', housed under '/etc/php5/apache2', in a text editor. Look for the 'upload_max_filesize' and 'post_max_size variables' and change their value from '2M' to something like '1024M' or even '2G'. Optionally, on larger installations, you can also install the APC PHP accelerator to make the OwnCloud installation snappier. Pull in the components with `sudo apt-get install php-apc` and then open APC's configuration file and add:

```
$ sudo nano /etc/php5/
conf.d/20-apc.iniextension=apc.
so apc.enabled=1 apc.shm_
size=12M
```

Then bring the cache online by restarting Apache with:

```
$ sudo apachectl restart
```

3 MOUNT THE DRIVE

Now that the server is set up and configured, it's time to prepare the storage medium. Plug the USB disk into the Pi and enter `sudo blkid` in a terminal. The USB disk is probably mounted as '/dev/sda1' if you don't have any other USB disks attached. Make a note of the corresponding UUID, which looks something like '6154-F660'. Now create a directory to mount this drive using:

```
$ sudo mkdir /media/owncloud
```
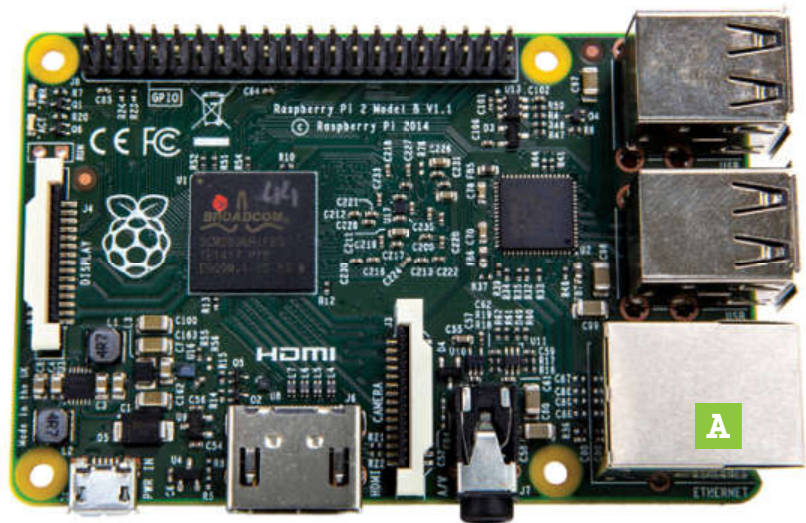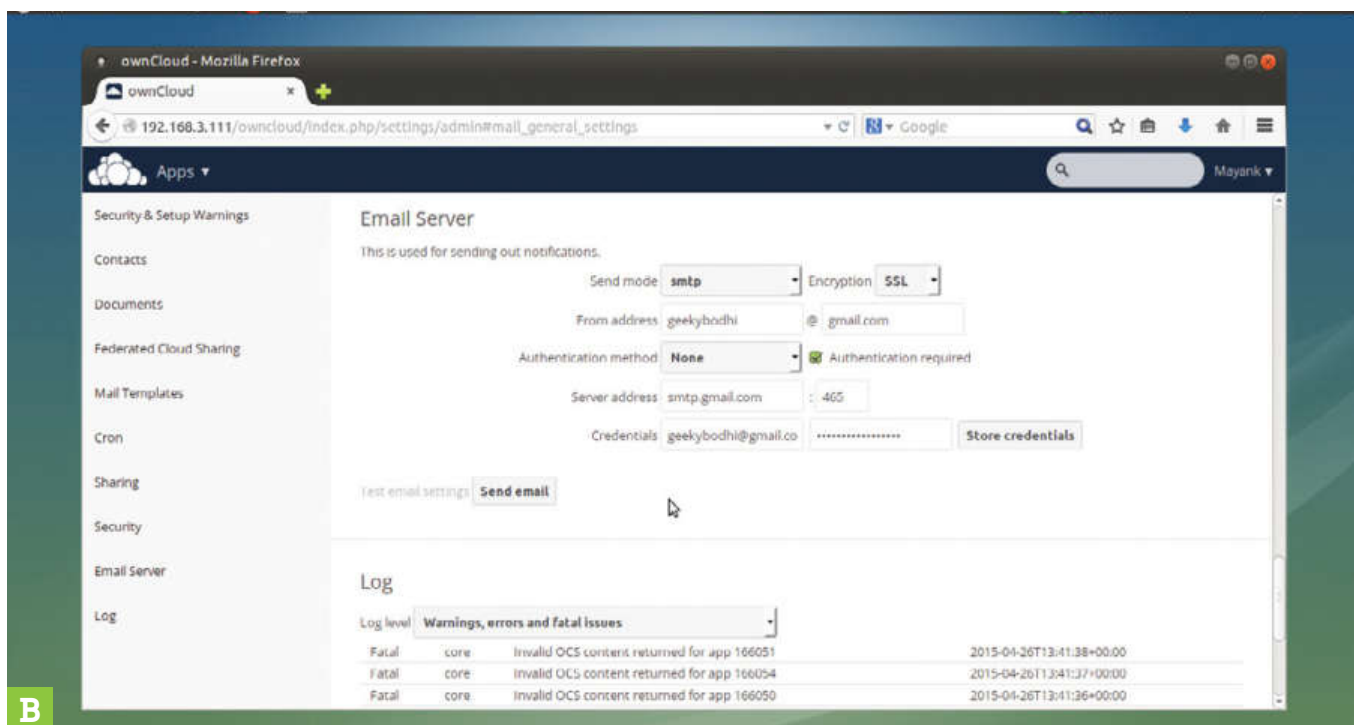
Then mount the drive with:

```
$ sudo mount -t vfat -o
umask=007,auto,uid=33,gid=33 /
dev/sda1 /media/owncloud
```

The above command assumes your drive has a FAT32 filesystem and is mounted at '/dev/sda1'. Once the drive is mounted correctly, you can edit the 'fstab' file to make sure it's automatically mounted:

```
$ sudo nano /etc/fstab
UUID=6154-F660  /media/
owncloud/  vfat
rw,umask=007,auto,uid=33,gid
=33 0 0
```

4 CONFIGURE THE CLOUD
That's all there is to installing the server components. You're now all set to configure your cloud. Launch a web browser and navigate to the OwnCloud installation instance at '192.168.3.111/owncloud'. Because this is a brand new installation, you're asked to create a new user account for the OwnCloud administrator.

Next, we need to ask OwnCloud to use the MySQL database and store files under the mounted USB drive. For this, click the 'Storage & Database' pull-down menu. Then enter `/media/owncloud/data` in the text box corresponding to the 'Data Folder' entry and select the 'MySQL/MariaDB' option in the 'Database' section. You're asked to enter the connection details of the database server, so just enter `localhost` as the host and `root` as the username, along with the password you configured when the database was

pulled in along with OwnCloud. That's it — you've set up OwnCloud. You can now log into your cloud server as the administrator using the credentials you've just created.

5 CHANGE SETTINGS
While you can start using the

server to upload and download files straight away, let's take a moment to get your house in order. For starters, when you log into the OwnCloud server, click the pull-down menu next to your username and click 'Personal'. Here you can change the settings for your account, such as the login password

Ready-made solutions

Although it doesn't take too much effort to install and configure the OwnCloud server from scratch, there's a couple of ways to save time and effort. The guys behind PetRockBlog have written a script that automates the whole installation process. The script downloads and sets up an OwnCloud installation on top of a Raspbian distribution. However, unlike our tutorial, the script uses the Nginx web server, instead of the Apache web server. To use the script, install the required components with:

```
$ sudo apt-get install git dialog
```
Then download the script with:
```
$ git clone git://github.com/petrockblog/ OwncloudPie.git
```
which creates a directory called OwncloudPie. Move into this directory:
```
$ cd OwncloudPie
```
Make the script executable:
```
$ chmod +x owncloudpie_setup.sh
```
Then execute it:
```
$ sudo ./owncloudpie_setup.sh
```
Give it some time to download all the components and configure your server. Once you've installed OwnCloud from the script, you can run it again to update it whenever new versions are released.

If you're the adventurous sort, you can install arkOS (**arkos.io**) on your Raspberry Pi. In addition to OwnCloud, the distro has other apps to keep you in charge of your data. Head to the downloads page, then download and extract the installer for the Raspberry Pi. Insert an SD card and run the installer with:
```
$ sudo ./arkos-install
```
Follow the steps in the installer to download the image from the internet and install it on to your SD card. Once it's done, boot your Raspberry Pi from it and head to http://arkos:8000 to set up your server.

C
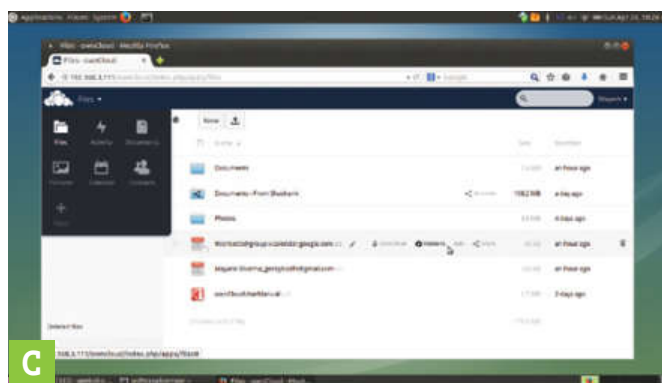
Image E
E

and display name. You can also add a profile picture and configure how you'd like to be notified about certain actions [Image B].

Also, if your cloud is going to be used by multiple people, it's advisable to add users and organise them into different groups. To do this, select the 'Users' option from the pull-down menu. While adding users, you can restrict their storage space and even share your admin responsibilities with other users, and mark certain users as admins for a particular group.

6 UPLOAD AND SHARE FILES
You're now all set to upload data into your OwnCloud server. After you've logged in, you are in the 'Files' section [Image C]. To upload a file, click the arrow button. To organise files into folders, click the button labelled 'New', and select the 'Folder' option from the drop-down menu to create a new folder.

If you've uploaded a file in a format that OwnCloud understands, you can click its name to view and edit the file. OwnCloud can visualise the data it houses in different views. For example, click the 'Files' pull-down menu in the top-left corner of the interface, and select 'Pictures'. This helps you view images in your cloud by filtering out all other types of content.

Another way to upload files to the server is by using the WebDAV protocol, with which you can access your cloud server from your file manager. For example, in the 'Files' file manager, press [Ctrl-L] to enable the location area. Here you can point to your OwnCloud server, such as 'dav://192.168.3.111/owncloud/remote. php/webdav'. Once authenticated,

D
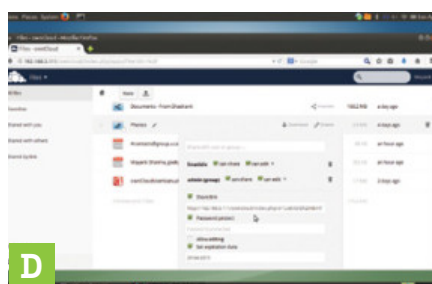
the OwnCloud storage is mounted and you can interact with it just like a regular folder.

To share uploaded files, simply go to the 'Files' section in the web interface and hover over the file or folder you wish to share. This displays several options, including 'Share', which enables you to select which users or groups you want to share the item with and whether you want to give them permission to edit and delete the files.

You can also share with someone who isn't registered with your OwnCloud server. Click on 'Share with Link', and OwnCloud displays a link to the item that you can share with anybody on the internet. You can also password-protect the link and set an expiration date too [Image D].

While you can interact with the cloud using the web interface, it's far easier to use one of its official clients. OwnCloud has clients for all the major desktop and mobile platforms. These clients also help you synchronise folders from the desktop to your OwnCloud server with ease.

7 SET UP CLIENTS
Most desktop distributions host the Linux client in their official repos. You can also grab the latest version by adding the corresponding repo for your distro from here: **tinyurl.com/ nve2vgt**. The page has instructions for popular distros including Debian, Fedora, Ubuntu, OpenSUSE and more.

Head to **owncloud.org/ install/#install-clients**, the downloads page on OwnCloud's website to download clients for other platforms. Mobile clients are best fetched from either Apple's App Store or Google's Play Store.

Once the client is installed, it prompts you for your login credentials in order to connect to the OwnCloud installation. Once connected, the Linux clients create a local sync folder named 'owncloud' under the home directory, such as '/home/bodhi/owncloud'. Any files you move into this directory are automatically synced to the server. You can also specify one or more directories on a local machine to sync
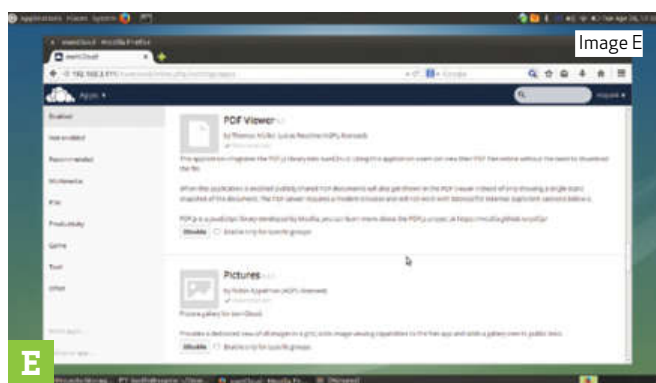
with the OwnCloud server.

If a directory is shared with several users, when anyone makes a change to a file on one computer, it automatically flows across to the others. When collaborating with other users, you'll appreciate OwnCloud's version control system, which creates backups of files before modifying them. These backups are accessible via the Versions pull-down option corresponding to each file, along with a Restore button to revert to an older version.

In addition to files and folders, you can also get your calendar and address book synced with your OwnCloud server.

8 INSTALL AND ENABLE APPS
You can extend your default OwnCloud installation by adding (or removing) a bunch of apps. Bring up the pull-down menu in the top-left of the interface and click 'Apps'. By default, you're shown a list of apps that are already enabled on your installation [Image E]. You can browse through this list and read their descriptions to understand them better. You can also disable any enabled app from this section.

Scroll down and click the 'PIM' tab on the left [Image F]. This section lists two apps. You can enable either or both the Calendar and Contacts apps. Once you've enabled both, the top-left pull-down menu now includes the Calendar and Contacts option.

Now you need to import your contacts and calendar from your existing apps into your cloud server. OwnCloud supports the popular vCard file format (which has the .vcf file extension) and almost every popular email app, including online ones such as Gmail, export their address books in this format.

Similarly, calendars can be imported in the iCal format. Before proceeding further, make sure you download both the .vcf and .ical files from your existing contacts and calendar apps.

Now, head to Contacts in OwnCloud and click 'Import Contacts'. In the pop-up window, click 'Upload File' and point it to the .vcf file. Once the

F

G
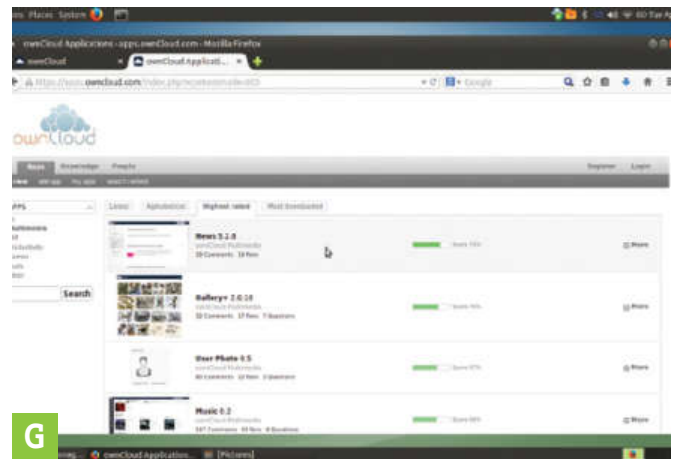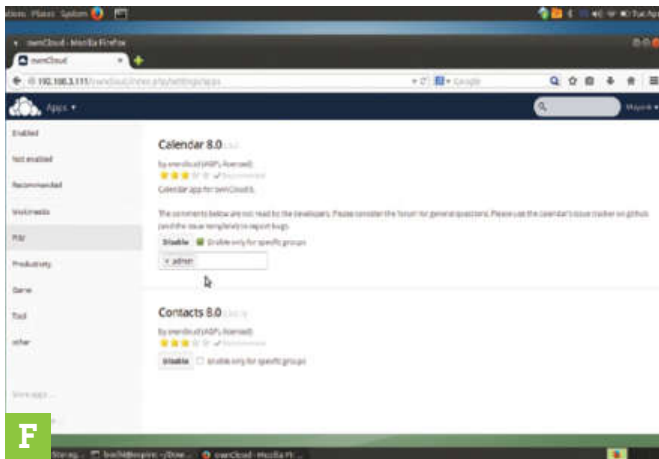
contacts have been imported, you can sync them with your email clients using CardDAV links. Head to the 'Contacts' section in OwnCloud, click the gears icon at the bottom, hover over the name of the address book you imported and click the 'Chain' icon. This spits out a CardDAV link for this address book that you can feed to your desktop or mobile address book client.

9 SYNC AND SHARE YOUR CALENDAR

Similarly, you can use OwnCloud to manage your calendar and tasks. To create an event in your calendar, head over to the Calendar app. You can view the calendar for the entire month or for the current week. To add a new event, click the appropriate date in the calendar. This brings up a window, which gives you several options to configure the event. To import an

existing client, simply upload the .ical file to your cloud server. When you click the file in OwnCloud's web interface, the server recognises the file and offers to import it into an existing calendar or into a new one. Select the option that best suits you.

After you've imported the calendar, you can use OwnCloud to share it with other users. Click the 'Share Calendar' icon corresponding to the calendar you wish to share. This brings up a pull-down menu, which enables you to select the users or the group of users you wish to share the calendar with. Furthermore, just like address books, OwnCloud can also sync your calendars with desktop and mobile apps that can read this information from CalDAV links. To get the CalDAV link for your calendar, click the 'Gears' button and then the 'Chain' icon corresponding to the calendar you wish to sync. This

displays the link that you can pass on to the clients to keep them in sync with the OwnCloud calendar.

There's a lot more you can do with OwnCloud. Explore the 'Apps' menus to find other ways to flesh out the default installation and extend the functionality of your cloud. In addition to the apps listed in the Apps section on your OwnCloud installation, there are others that you can install from the OwnCloud website. Scroll down the Apps section and click the 'More Apps…' link. This takes you to the OwnCloud store at **apps.owncloud.com** [Image G]. You can download any app from here and extract it under the '/var/www/owncloud/apps' folder inside the Pi. ■

Universal Access

The real advantage of commercial cloud services such as Dropbox is that you can access data stored within them from any computer connected to the internet. However, by default, a self-hosted OwnCloud installation is only accessible from computers and devices that are within the local network.

That's not to say that you can't access your private cloud from the internet. The trickier and expensive solution is to get a static IP address from your ISP and then poke holes in your router's firewall. Or, you can set up Dynamic DNS in your router or local machine.

The smarter way, however, is to use a tunnelling service, such as PageKite. The service uses a pay-what-you-want model. As a non-commercial user, you can use the service for free by filling out a form once a month, telling PageKite how you use the service. But if that sounds like too much hassle, it's definitely worth the $3 per month minimum it requests from individuals.

First, you need to install PageKite. Launch a terminal and enter:

```
$ curl -s https://pagekite.net/pk/ | sudo bash
```

When it's done, make your local web server public by entering the following command:

```
$ pagekite.py 80 mycloudserver.pagekite.me
```

Also, remember to replace 'mycloudserver' with the name you want for your OwnCloud server. Now you can access your own personal OwnCloud instance by heading over to http://mycloudserver.pagekite.me from any computer, anywhere in the world.

The first time you run this command, PageKite runs you through its brief sign-up process and will ask you for your email address.
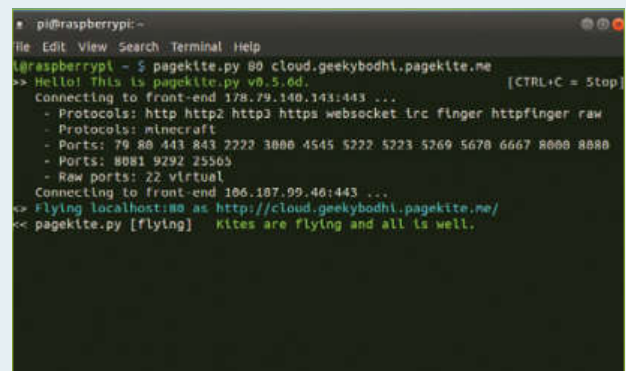
Digital direct – from cassette to smartphone

Your smartphone is a PC, so use it like one. Darren Yates shows you how to capture stereo analog audio straight to your smartphone or tablet for under $20.

Analog is cool. Hell, analog was always cool. If you grew up any time during the last quarter of the last century, you'd remember the compact cassette. We all knew well enough not to buy albums on cassette if you wanted the best audio quality, but for creating the ultimate mix-tape, cassettes totally rocked. Dutch giant Philips may have invented the Compact Cassette in the early 1960s, but by the late-80s, brands such as Nakamichi and Marantz using clever tech from dbx and Dolby pushed home-recorded audio quality to high levels. By the end, 'metal' tape could achieve an impressive 80dB signal-to-noise ratio (SNR) - it'd be ten years before CD burners were cheap enough to improve on that in the average PC.

If you think about it, the compact cassette was the world's first globally-successful mass storage device. According to USA Today, we hit 'peak cassette' in 1990, when we bought 442 million pre-recorded music cassette tapes — you can imagine the music industry yearning for those glory days again.

Still, it's funny how what goes around, comes around and old-school analog is making a comeback. Vinyl is hot and bands can even create new music on cassette — Dex Audio in Melbourne still does cassette duplication (**www.dexaudio.com.au/cassette.html**).

But if you think there's no cross-over in the analog and mobile digital worlds, think again. We're used to thinking any analog conversion requires a PC,

Acer's Aspire A200, one of the few Android tablets with a USB host port.

but there's enough low-cost tech available now to turn your Android smartphone or tablet into a stereo recording deck.

STEREO ADC

Most smartphones and tablets have a basic MEMS (micro-electromechanical system) microphone on-board, but it's not exactly 'high fidelity' and certainly not stereo. If you want maximum audio quality, you need a wired way to capture that awesome stereo analog sound — and that means a stereo analog-to-digital converter (ADC). Its job is to sample the audio at regular intervals and turn it into a stream of 16-bit stereo soundbites. Smartphones and tablets typically don't have this

tech on-board — but virtually every Android device since Ice Cream Sandwich/4.0 has a USB host port, either directly or more commonly through a USB OTG port.

Since last month, we've found a couple of new low-cost options that work with Android smartphones and tablets and, with the right software, capture analog stereo audio.

USB CASSETTE PLAYER

One of the big problems with cassette decks today is maintaining them — not the electronics, the main issue is deterioration of the drive belts. They age, go brittle and just fall apart. In an

This $18 Walkman-style cassette player has built-in stereo ADC and USB port.

Make a crude Dolby-B decode filter using Onkyo's free HF player on Google Play.

This $13 cable ADC features stereo RCA sockets and 3.5mm stereo plug for options.

Marantz's CP430 cassette deck – three heads, goes anywhere.

age where nothing is repaired any more, you either have to become your own electronics repair technician or just walk away. But eBay being the Aladdin's Cave of Tech that it is, we've found something of a simple compromise. The Super USB Cassette Capture is a one-stop shop cassette player with built-in stereo ADC and USB output. It's no Nakamichi CR-7 (if you're used to pitch-perfect digital, this low-cost player has a bit of wow and flutter), but there are some nice touches. First, you can use it as a Walkman — two AA batteries and you're away. If you're desperate, it even comes with a pair of earbuds. But more cleverly, the rotary volume control is set before the stereo ADC, allowing you to vary the audio level before sampling if you need to. There's also a 3VDC socket for external power. For $18 including shipping from China, it's not bad.

CONNECTING IT TO YOUR PHONE

The Super USB Cassette Capture comes with a USB Type A to miniUSB cable, so all you need is a USB Host port or, if necessary, a USB OTG cable. Plug the USB OTG cable into your Android phone, plug the Type-A plug end of the USB cable into the OTG port and the other end into the USB cassette player.

We've looked at it a couple of times now, but our go-to app for this job is USB Audio Recorder PRO from eXtream. It's a bit pricey for a mobile

app at $10, but it's easily the best at what it does. You'll find it on Google Play and it should work a treat. To test before you buy, grab the free trial app from **www.audio-evolution.com/downloads/USBAudioRecorderPROTrial_1.4.0.apk**.

USB AUDIO CAPTURE

But if you're a bit of an audio purist, the last thing you'll want to do is put your pristine cassettes through an unknown player. And to be honest, the mistake most people commit is thinking they need a playback device with a built-in USB port to digitise the

The USB cassette player ADC supports 48kHz/16-bit stereo capture.

Select the Mixer tab and set the sliders to adjust audio levels.

USB Audio Recorder PRO's monitor option lets you set levels before you record.
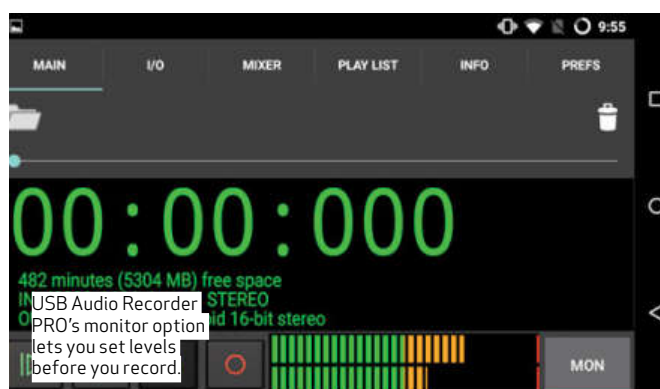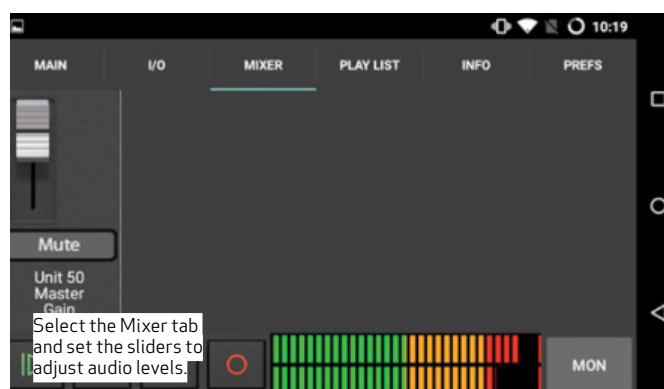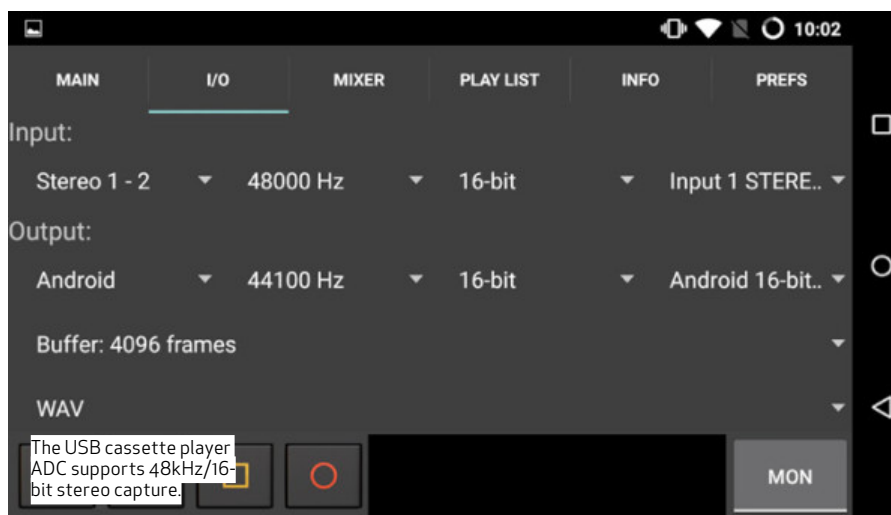
sound. To get the best audio quality, stick with your highest quality audio device — your Nakamichi CR-7 if you have one — and convert the analog audio to digital externally. Personally, I use my old Creative Sound Blaster Audigy 2 NX and Extigy USB boxes for this, but depending on how fussy you are, there is a $13 option that might do the trick.

This EzCAP cable features a USB Type-A plug on one end and your choice of two RCA female sockets or a 3.5mm stereo male plug on the other with a little black box in the middle housing the stereo ADC. As for the cables, get your own stereo RCA cables to connect the line-out outputs of your cassette deck to the ADC cable and again, plug the USB end into the USB OTG cable on your phone or tablet.

USB Audio Recorder PRO had no trouble picking up this one, either, offering 48kHz/16-bit stereo capture straight off the bat — that's thanks mostly to its own built-in USB Audio Class device drivers. Android only began offering native USB Audio class drivers as of Lollipop/5.0, so having its own USB drivers means USB Audio Recorder PRO will work on just about any Android device from ICS/4.0 and up.

The one drawback with this audio capture cable is that, unlike the USB cassette player, it has no on-board audio level adjustment — and USB Audio Recorder PRO's mixer slider doesn't seem to work here. That's a bit of a problem because the cable ADC is set to handle a maximum 2Vrms CD-level input, which gets the digitised audio level up to 0dBFS. Using a cassette deck delivering the usual but lower 775mVrms line-out level however, it ends up a bit lower on the scale than you'd ideally like.

SIMULATING DOLBY DECODING
The USB cassette player also has a potential drawback — given its price,

No Type-A USB port on your Android device? A USB-OTG cable is a must.

USB Audio Recorder PRO has its own USB audio class device drivers. FTW.
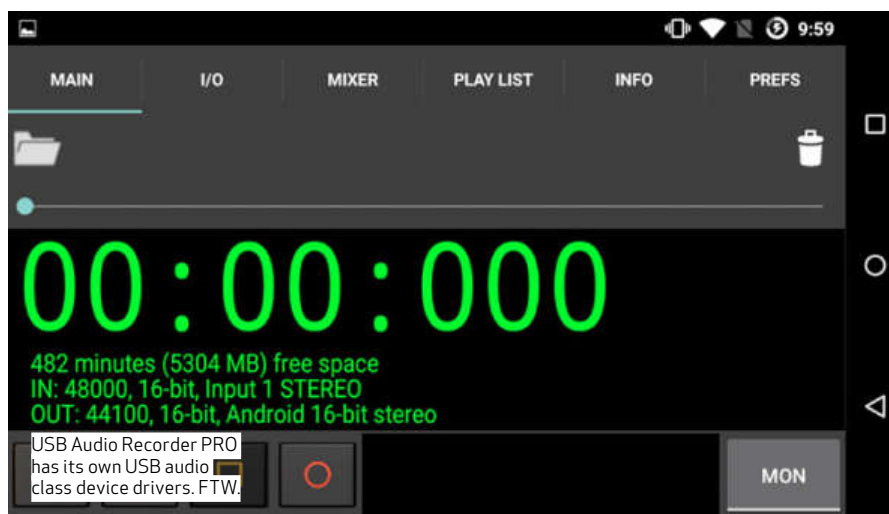
there's no Dolby noise reduction on-board, so anything originally recorded with Dolby B, C or dbx is going to sound quite a bit 'trebley'. Now Dolby is (still) a heavily patented technology and there are no free Dolby decoding filters available for apps like Audacity. Even Dolby B, the most common consumer-grade version, is quite complex and uses signal-amplitude compression filtering techniques that are difficult to replicate manually.

But thanks to Georgia State University for the basic specs (**tinyurl. com/ogr63u7**), a simple, crude solution is to run the captured audio through a graphic equalizer app on your Android device. You need something like a 6dB-per-octave low-pass filter starting at 200Hz or so with a bottom of about -10dB thereafter. It ain't 'genuine', but the result gets you somewhere near the same postcode.

The cassette player also has something of an azimuth adjustment — a tiny screw to correctly align the replay head's horizontal axis with the actual tape. But annoyingly, the plastic shell holding the head in place covers the screw when the tape drive is in play mode, making it mostly pointless, unless you're prepared to cut/drill some of the plastic away and then it's

all getting a bit much.

Ideally, the best option will always be to run your tapes through the deck they were recorded on, or failing that, play them back on a deck with the correct Dolby standard to get something like the original frequency response back again.

That's where the EzCAP cable is a more workable solution. If it just had adjustable output audio level, it'd be perfect for phone use as opposed to being just 'reasonably good'. Still, for something that costs $13 and works with your Android smartphone or tablet, it's not a bad result.

AUDIO PLAYBACK APP
If you're looking for a decent Android music player, give Onkyo's free HF Player app a go for two reasons. First, it has a customizable graphic equalizer you can draw your desired frequency response (nice). But second, it supports playback through USB devices, so if you have something like the Burr-Brown PCM2704C USB DAC we looked at last month, it works a treat. Just look up 'Onkyo HF Player' on Google Play. You'll need Android 4.1/Jelly Bean minimum, though. We tested the app on our Lillopop'd Galaxy S3 and it worked nicely.

EXPENSIVE STORAGE BOX

Hopefully, you can see that your tablet or smartphone is simply now just a glorified digital stream recorder and storage box. Once the ADC process is complete, it doesn't matter whether you plug the cable and record that stream into a PC or smartphone, the audio quality recorded via that ADC is exactly the same.

POWERING THE USB CASSETTE PLAYER

There was one interesting thing we found with the cassette player — although it supports two AA cells, they don't make the slightest bit of difference once that USB cable goes in. Whether those cells are there or not, the player consumes approximately 170mA of current measured from the USB cable. If you have a tablet with separate power, that current load shouldn't be a problem. Nor did we have any trouble powering the cassette player from the USB OTG cable on our Samsung Galaxy S3 smartphone and its battery. The problem, though, is that without external power, a 170mA-drain will cut battery life by anywhere up to half, depending on your device's battery capacity, so it's something to keep in mind.

RECORDING FROM ANALOG SOURCE DIRECT TO SMARTPHONE

Dubbing from an analog source to your smartphone is easy. Here's what you do:

STEP 1:
Get USB Audio Recorder PRO — it'll cost you $10 on Google Play (test the free trial app first). You need at least ICS/Android 4.0.3 on your device, a USB OTG port and a USB-OTG cable with microUSB on one end and a Type-A USB socket on the other.

STEP 2:
Grab either of the stereo ADCs we've talked about. If not one of those, there are many USB ADCs supported by USB Audio Recorder PRO — check the web site at **tinyurl.com/ngdz3og**.

STEP 3:
If using a line-level ADC, connect the line-out outputs from your audio source to the ADC and plug the USB end into your phone via the USB OTG cable.

STEP 4:
Launch USB Audio Recorder PRO and you should see the 'access the USB audio device' prompt. Select OK and basic ADC specs should appear on screen.

STEP 5:
Press the Monitor button on USB Audio Recorder PRO and start playing your source audio. Select the Mixer tab

Plug the USB ADC into your phone before launching USB Audio Recorder PRO.

The rotary volume control can set the output level in your digital recording.
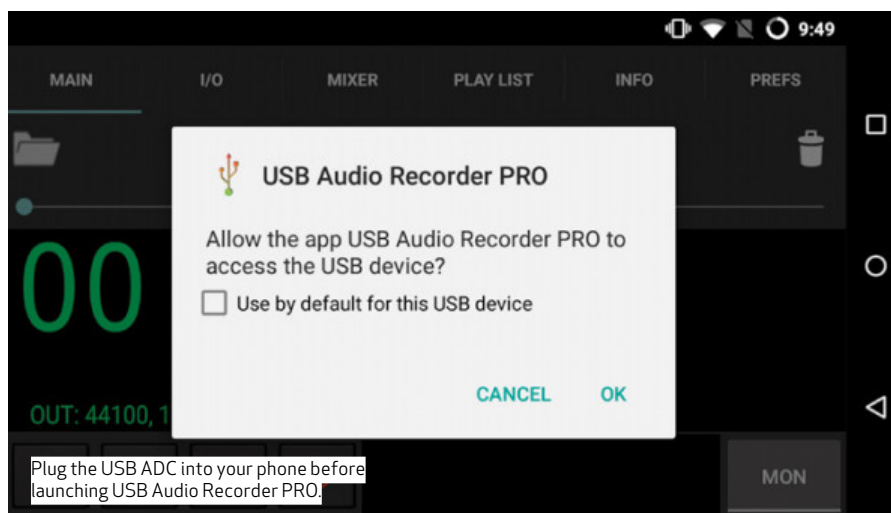
on the app, try to locate the loudest passage of your source audio and set the mix level so that the peak-program (VU) meter gets close to the 0dBFS (full scale) without hitting it. This should give you the cleanest, least-distorted sound.

STEP 6:
Ensure you have sufficient space for the running time of your audio source. For WAV-format recording at 48kHz/16-bit stereo, you'll need around 700MB per hour. Once you're ready to go, begin recording by hitting the red button on the app and start your audio source. Once complete, hit the stop button.

STEP 7:
Press the green Play button on USB Audio Recorder PRO to play back the file you've just recorded and check the quality. The benefit of line-level recording is that you shouldn't get any

Our Lollipop'd Galaxy S3 recognised both USB ADC devices.

interference from other sources, so the quality should be as close as possible to the original.

MIXTAPES LIVE ON

Nothing brings back the sounds of the 80s and 90s as you remember them quite like your old mixtapes, so if you have yours still in a box in a cupboard somewhere but nothing to play them on, $30 for a USB cassette player and a stereo audio recording app will have you rolling back the years in no time — and with no PC in sight. ∎

Take control of the Arduino MP3 player

Darren Yates shows you how to add volume, play, next and previous track buttons to last month's Arduino MP3 player.

This $3 power pack from eBay turns two AA cells into 5VDC USB power.

The VS1053 Shield is the easiest way to turn an Arduino Uno microcontroller board into a multi-codec digital audio player. You'll find it on eBay for as little as $12.50 including shipping. It can record audio to OGG format and plays a range of codecs, the easiest to code your Arduino device for being MP3.

Last month, we made the simplest MP3 player possible — plug in the power and it plays whatever MP3 files it finds on the card. This month, we build on that version, adding Volume Up and Volume Down controls, Previous Track and Next Track buttons, plus a combo Play/Pause button — and their code.

MAKING THE STACK

To build up our player, we've combined an Arduino Uno with the VS1053 Shield and a small Prototype Shield that comes with a tiny breadboard. Put simply, you plug the VS1053 Shield into the Arduino and the Prototype Shield into the VS1053 Shield. Power automatically runs to each board, so you only need to plug in a USB cable and all three boards are active.

MOMENTARY-ON PUSHBUTTONS

We've installed five small 'momentary-on' pushbutton switches on the breadboard, arranged as a row of three and column of two. The column is the audio level/volume buttons, while the row is Previous Track (left), Play/Pause (middle) and Next Track (right). So instead of simply getting what you're given as with our first build, you now have a full-function audio player.

These buttons are called 'momentary-on' because that's what they do — left alone, the switch is in the 'off' (no connection between the two pins) position, press down and the switch is on (contact), but only while it's pressed. Let go and it goes back to the 'off' position.

OVERLAY DIAGRAM

The overlay diagram shows what's going on. Each switch connects between the ground plane (GND) and

one of the analog inputs, A0 through A4. We're also using the built-in 'pull-up resistor' inside each of those inputs to enable us to track when each button is pressed. In the off position, each input is pulled high by the internal resistor to the 5V supply rail, a digital '1', indicating the button isn't being pressed. But as soon as it is pressed, the button pulls the input to GND, a digital '0'. By continually reading these inputs, we can tell which button is being pressed and perform an action appropriately. And that's about it — by plugging the stack together, you create the rest of the circuit. We've used Dupont wires to make the switch connections — again, 65 of these can be had on eBay for a couple of dollars.

DEBOUNCING

These tiny switches are mechanical, they have moving parts. But because of that, they don't make a clean contact when you press them. If you could zoom in and see what happens over the first half-second or so, the switch contact 'bounces' into position — and that's a problem. If you're waiting to detect a press on that button, you're looking for a change of level from '1' to '0'. But if you're getting '100010101011100' in the first 50-milliseconds, you've got multiple triggers, not just the one. In electronics, this is solved with a 'debounce circuit', essentially a resistor-capacitor filter on the switch
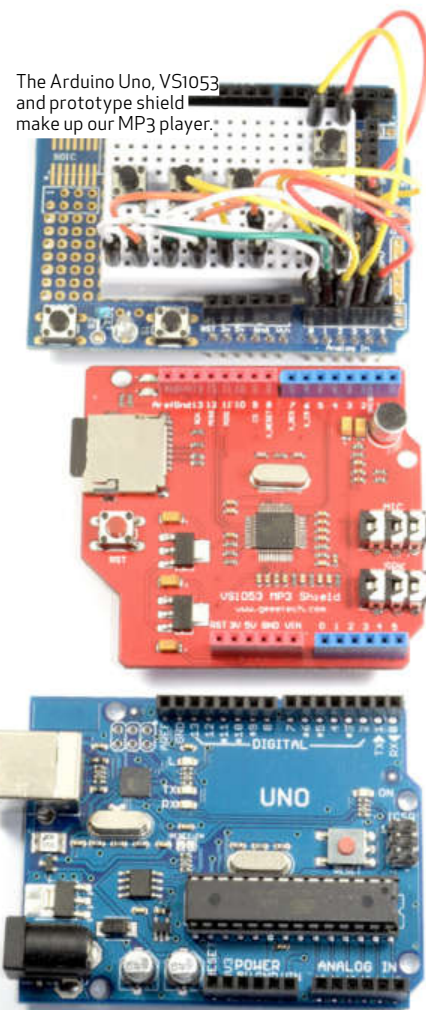
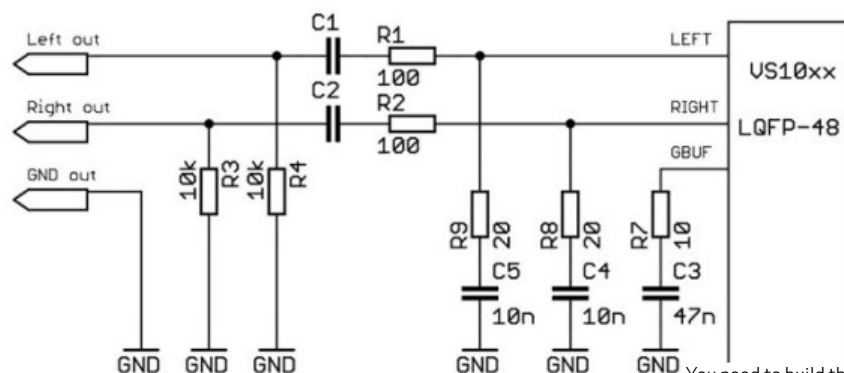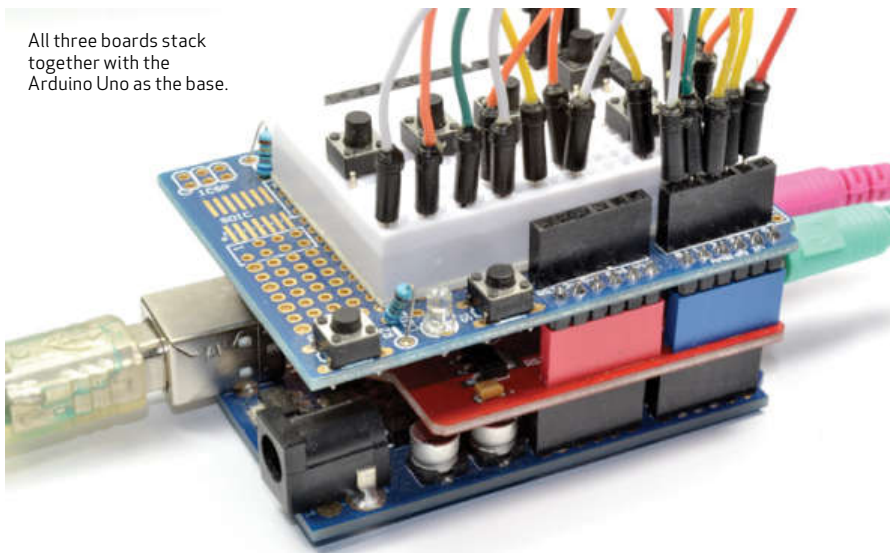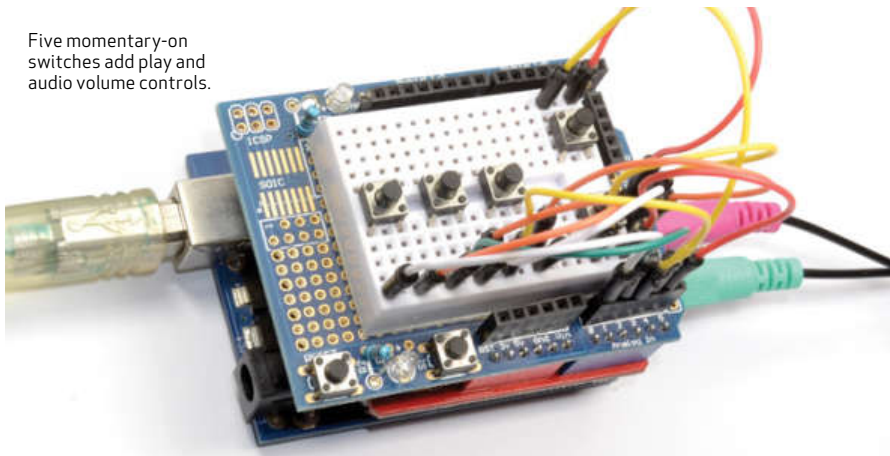The Arduino Uno, VS1053 and prototype shield make up our MP3 player.

Figure 8: Simple line-out connection

You need to build this circuit to connect the MP3 audio output to an amplifier.
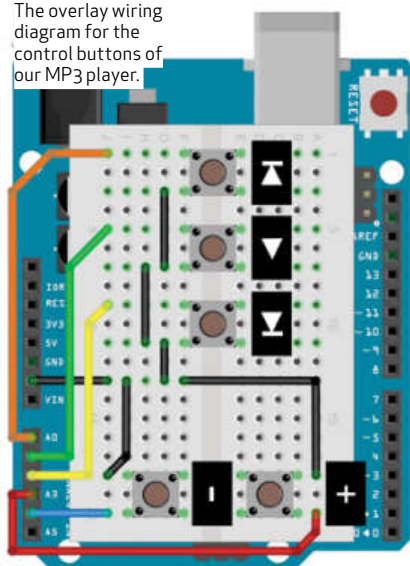
All three boards stack together with the Arduino Uno as the base.

Five momentary-on switches add play and audio volume controls.

The overlay wiring diagram for the control buttons of our MP3 player.

feeding a logic gate called a 'Schmitt Trigger', but here, we're implementing an extremely crude debouncer in code — a simple time delay. As soon as we detect a change on one of the input lines, we set off a 300-millisecond time delay, which is enough to allow these switches to settle into their steady-state position. It's also easy to implement because it's just one line of code: `delay(300)`.

It does mean we can only detect one change every 300-milliseconds, but that's enough here. We've tested the code (very enjoyably, I might add) and it works a treat.

FILE FORMAT

You still need to have your MP3 files in the format 'track001.mp3', 'track002.mp3', track003.mp3' and so on. This '8.3' filename limitation comes from using the playTrack(int) command that takes just a single 8-bit integer — file-renaming apps can sort this out for you pretty easily. This method does limit you to 200 tracks, but other than that, you can have full 48kHz sampling up to 16-bit stereo at 320Kbps bit rate. Why not standard Windows long filenames? Well, with only 2KB of RAM to play with, there's only so much an Arduino Uno microcontroller can cope with. Still, when creating a blank Word 2010 .docx document requires 13KB, the Arduino isn't doing too badly here with just 2KB.

The VS1053 MP3 Shield does all the heavy lifting, making data into audio.

POWER SOURCE & VS1053 LIMITATIONS

Lastly, the VLSI VS1053 audio codec chip that makes this project possible was originally designed for stand-alone battery-powered (3.3VDC) use, so it implements a separate audio ground that's not at normal ground voltage (0V). Instead, it sits at 1.25VDC. If you decide to connect this using a 3.5mm cable to a powered speaker system, you'll create what's called a 'ground loop', which is where current will automatically flow from that 1.25VDC source into the ground plane. That won't do the VS1053 chip any good — in fact, it'll like blow up that part of the circuit. The solution is to stick with headphones, or if you're clever, you can implement the 'simple line-out connection' circuit, which solves the exploding problem.

Finally, if you're listening to this MP3 player with headphones, we recommend you power it with a USB battery power pack that delivers 5VDC to a Type-A USB port from a Lithium-ion battery or AA-size cells. Avoid powering it with a cheap USB charge adapter — if something fails in one of those things, you could have 240VAC power disappear up your headphone cable. Don't risk it. ■

Java games development, part 3

If coding flight arcade games isn't your thing, how about a driving game instead? As Darren Yates explains with a new game called *Overtake*, there's plenty of similarity.

At the risk of showing my gaming prowess (or lack thereof), my very first computer game was *Digital Derby* by Tomy — though, calling it a computer game is a bit generous. Forget finding a CPU inside, this one had barely any electronics at all. But I couldn't care less — it was one of those glorious electromechanical games that slurped through two C-cell batteries as you drove your race car, overtaking the slowcoaches while trying to avoid becoming roadkill from on-coming traffic. If you smacked into someone, you had to press the reset button for a three-second penalty and you were off again, since speed was the key — the faster you went, the higher your score. Totally boring, probably, by today's standards, but for 1978, it totally rocked!

Being a simple game, it's also ripe for coding practice. What might surprise you is that we can use the same basic code structure as last month's air combat arcade game.

GIVE YOURSELF A TIME LIMIT
One of the problems you can have when coding is 'scope creep', that nasty habit of dreaming up more and more brilliant ideas that turn your once-simple game into a mega-epic that now needs five full-time coders to finish. So as an exercise, I gave myself eight hours to get this game up from concept to car-crash (in a good way). Sometimes, giving yourself a time limit can help you focus on the must-haves and get something working. Once you've got the basic shell of your game up and running, you can go again with another time-limit and add new features to sweeten it up (in project management, this is kind-of, sort-of the 'agile' approach.)

MOCK-UP
The first step was to come up with a game layout mockup, which broadly follows the *Digital Derby* original, with the driver's car at the bottom, moving left to right. On-coming traffic comes straight down the opposite lane,

Don't slow down too much or you'll get hit from behind.

We're using the fireball from last month's air combat sim to good effect.

Making simple game backgrounds is easy enough to do with Paint.Net.
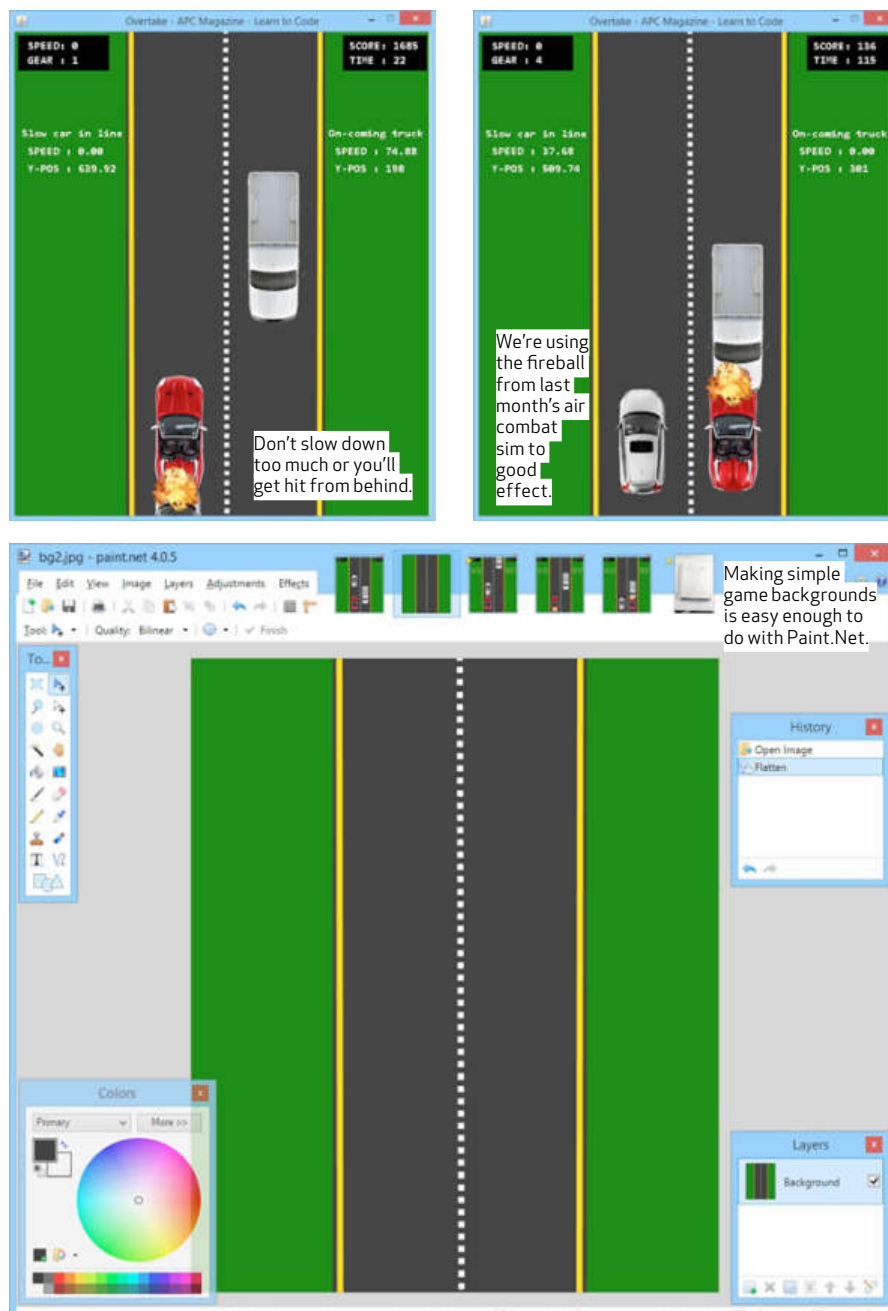
while slow cars have to move both forward and back (up and down), relative to the speed of the driver's car. And of course, the driving lane is on the left (correct) side of the road. While the original game had a genuine three-speed manual mechanical gearbox(!), coding our game as a four-speed automatic would cut down on controls required and save coding time.

Digital Derby was one of the first hand-held 'electronic' driving games.

All games use loops, but Digital Derby does the real thing.

Inside the 1978-vintage Digital Derby – simple electronics, complex gearing.

FRAME, BACKGROUND IMAGE

With a reasonable mockup in hand, we can now get to work on the game frame. Given that everyone has at least a 1,024 x 768-pixel panel to view, it made sense to keep the game dimensions to 600 x 720-pixels and lock off frame-resizing. To keep things simple, the background image doesn't move or scroll, allowing me to create a crude but serviceable road landscape in Paint.Net. Top-down view images of cars were sourced from Google and scaled to size (if this was a serious effort, the cars would also have been drawn).

GAME STRUCTURE

We talked about game structure before. This is important because it helps you figure out game mechanics and how everything interacts — and it'll help if we use Classes. Our game here has only three classes — Car, SlowCar and CarOnComing. Each car class has position information or attributes — the SlowCar and CarOnComing have fixed X-axis (horizontal) position, the Car class, fixed Y-axis (vertical) positioning. They all have speed attributes, but the Car class additionally has Score and Hit attributes.

As for class functions or methods, each has a move function to handle movement while the Car class also has a 'checkHit' method to see if the car has hit anything.

ANIMATION VIA TIMER CLASS

As we did with our air-combat arcade game last month, we've incorporated a timer that governs the animation. Every 25-milliseconds, the timer fires and runs the animate instance of the TimerListener class. Each time that class fires, it increments all screen movements as necessary. Triggering every 25-milliseconds means we have a game frame rate of approximately 40 frames per second.

There are several things it checks each time — first, it looks to see if timeRem is greater than zero. The game is timed to last two minutes (120 seconds), but instead of using another timer, we just set an integer called timeRem to a start count of 4800 and use the animation timer clock to decrement it. If that timer fires 40 times per second, it'll take 4800 / 40 = 120 seconds to count down to zero. Two minutes, give or take (the timer isn't perfectly accurate).

J-BITS

As for the game layout, the app — our Overtake class — extends a JFrame (remember, extends means we want all of the standard features of a JFrame, but we also want to add our own code). And on that JFrame, we add a JPanel extended class we've called Road. It's this JPanel that everything is drawn onto using the standard paintComponent method.

Going back a step, the JFrame constructor creates the frame, creates new instances of the car classes as well as adding an instance of the Road class to the frame — this lays the foundations by creating all the basic object instances we need. It's also where we keep the KeyListener called KeyChecker. Remember that to listen out for when keyboard keys are pressed, we attach a KeyListener to the frame, which fires as soon as any key on the keyboard is tapped. We're interested in six keys only — the four arrow keys, along with 'Y' and 'N' for the user to answer whether they wish to play again.

The data on which keys are pressed comes back in the 'e' KeyEvent system variable and we use the various KeyEvent constants such as 'VK_UP', 'VK_DOWN' and so on to check which key was pressed. However, we need to add a bit more to it. Normally, if you hold down a key, your computer registers a single key press, and after a time, repeat key presses are loaded into the keyboard buffer. The problem is that the time delay between the 'one' and the 'many' is a real pain, particularly if you're trying to steer away from on-coming traffic!
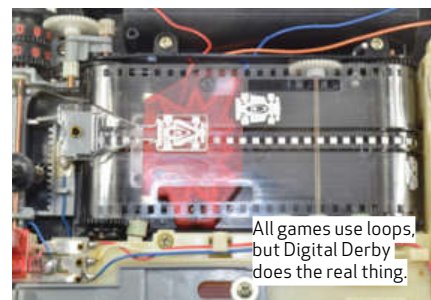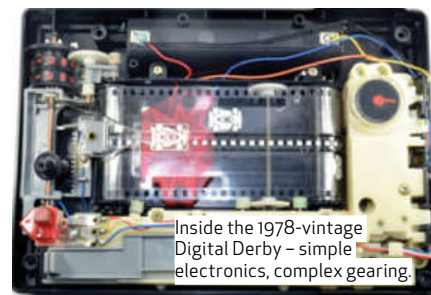
So, instead, we use the key press to set the value of a cell in an integer array. If a key is pressed, the designated array integer is set to '1', flagging we're to launch a function continuously. If the key is released, that integer is reset to '0' and stops. This way, we escape the keyboard buffer delay and the game instantly recognises you want multiple repeated actions immediately (such as steering movement). It also recognises multiple keys at once, so you can accelerate or brake and steer at the same time.

ANIMATION

The timer class we mentioned before that handles our animation is located in the JPanel class, along with the 'paintComponent' method that does the drawing. Each time the timer triggers, the TimerListener also calls the move methods in each of the three car classes. Depending on their speeds, the Y-axis position attributes are incremented and decremented by small amounts on each timer trigger and then drawn by the paintComponent method, giving us animation.

One of the tricks used by *Digital Derby* was to have two plastic loops with car decals to give the impression that you're driving down this continuous road. We've taken this 1970s' view of looping and given it a 21st-century coded update.

In Java, '0' is always the top of the frame and the bottom of the frame is available from the getHeight() system method. The SlowCar image is 150-pixels tall, the bigTruck is 200-pixels — that means in order to have these vehicles disappear above the screen, we need to take their Y-positions to -150 and -200, respectively. This is done by decrementing the 'y' attribute. However, once they reach -200, there's little point having them disappearing further off screen, so to give the impression of looping, we reset the position to 'getHeight() + 300', which is some way below the bottom of the screen. Since the decrementing of the 'y' attribute is governed by other code, the car continues to move upwards, appearing from below the screen frame. The original purpose of the loop in this game was to give the impression of multiple cars and that's what we've now got. We won't explain it but we also do the same thing for on-coming traffic — anything below 'getHeight() + 300' gets reset to -200.

MOVEMENT VECTORS

Now obviously, we're not making *Forza* here, but some simple physics using the concept of 'relative velocity' will help make our game look right.

Think about when you're travelling in a car or train — cars travelling in the same direction appear to move slowly, relative to each other; vehicles travelling in the opposite direction appear to move exceedingly fast. In physics, you'd say each vehicle had a vector — a velocity (speed) and direction. When you're adding simple vectors together, the relative velocity of two vehicles travelling in the same direction is the fastest minus the slowest. So if you're in one car doing

A game mockup is always a good idea (and no, you have to be a Picasso).
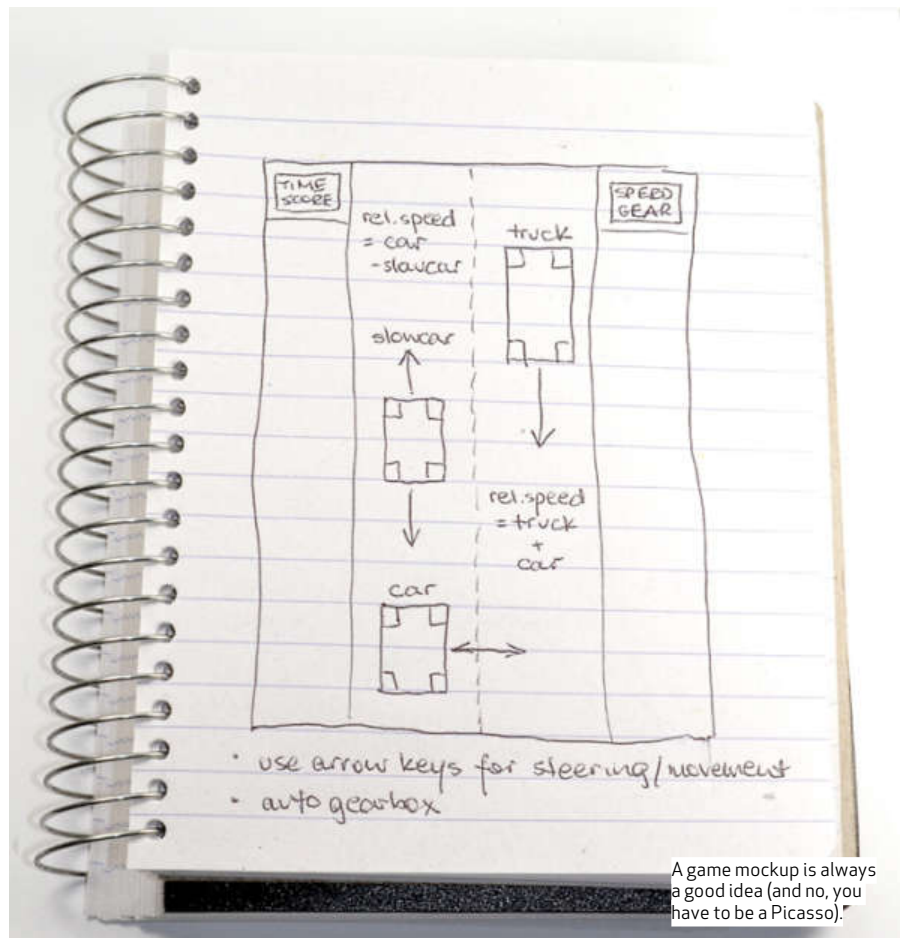
110km/h and another car next to you is doing 90km/h, relative to that slower car, it'll seem like you're pulling away at 20km/h. But for two cars travelling in opposite directions, you still subtract one vector from the other, but the difference is that the vehicle travelling in the opposite direction is treated as a negative vector. For example, you're still doing 110km/h in your car, but this time, the car doing

90km/h is going in the opposite direction. Now, the subtraction of vectors becomes 110km/h – (−90km/h) = 110 + 90 = 200km/h. Relative to the car travelling in the opposite direction, it looks as though you're travelling at 200km/h.

If you look at the SlowCar and CarOnComing classes and their respective move methods, you'll see that for the SlowCar class:

```
y += (car.speed - speed) /
20.0
```

But for the CarOnComing class, it's:

```
y += (car.speed + speed) /
20.0
```


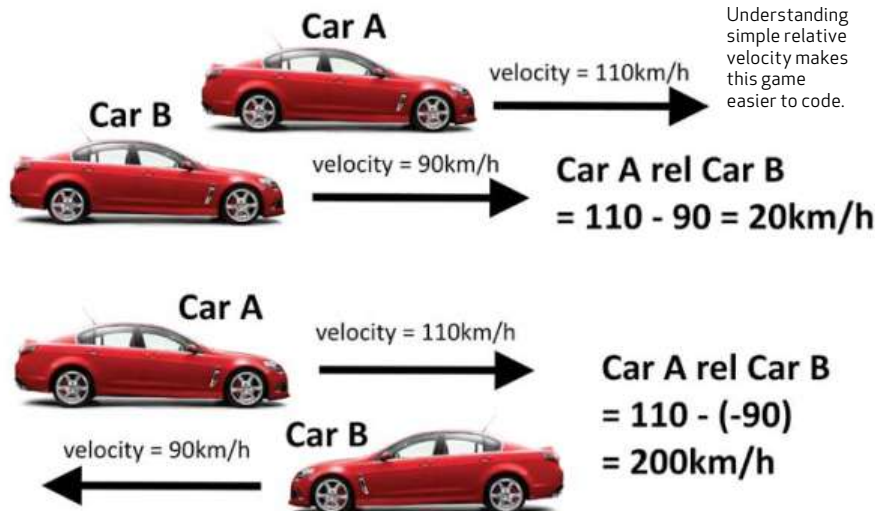Load the game into NetBeans on Linux and it looks and runs much the same.
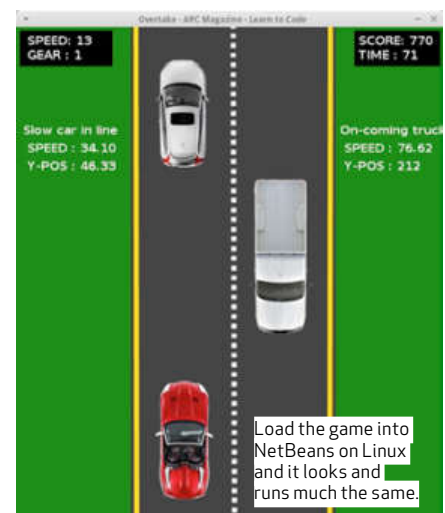
```java
class KeyChecker implements KeyListener {
    @Override
    public void keyPressed(KeyEvent e) {
        if (e.getKeyCode() == KeyEvent.VK_LEFT) { keyControls[0] = 1; }
        if (e.getKeyCode() == KeyEvent.VK_RIGHT) { keyControls[1] = 1; }
        if (e.getKeyCode() == KeyEvent.VK_UP) { keyControls[2] = 1; }
        if (e.getKeyCode() == KeyEvent.VK_DOWN) { keyControls[3] = 1; }
        if (e.getKeyCode() == KeyEvent.VK_Y) { initialiseApp(); }
        if (e.getKeyCode() == KeyEvent.VK_N) { System.exit(0); }
    }

    @Override
    public void keyReleased(KeyEvent e) {
        if (e.getKeyCode() == KeyEvent.VK_LEFT) { keyControls[0] = 0; }
        if (e.getKeyCode() == KeyEvent.VK_RIGHT) { keyControls[1] = 0; }
        if (e.getKeyCode() == KeyEvent.VK_UP) { keyControls[2] = 0; }
        if (e.getKeyCode() == KeyEvent.VK_DOWN) { keyControls[3] = 0; }
    }

    @Override
    public void keyTyped(KeyEvent e) {
    }
}
```

The KeyChecker class listens out for your keyboard key presses.

Understanding simple relative velocity makes this game easier to code.

Car A
velocity = 110km/h

Car B
velocity = 90km/h

Car A rel Car B
= 110 - 90 = 20km/h

Car A
velocity = 110km/h

velocity = 90km/h

Car B

Car A rel Car B
= 110 - (-90)
= 200km/h

In each case, speed refers to the class attribute, so SlowCar.speed and CarOnComing.speed, respectively. But here, we either add or subtract the speeds to get the correct relative velocity and use that to increment the Y-position. The reason we divide the increment by 20 is to scale the movement down to fit our JFrame panel and give you enough time to judge when to move. (Here's a tip, change the '20.0' to '5.0' and see how playable it is — its not!).

CALCULATING SCORES

Scoring in the game is based on the driver's car speed — the faster you drive, the faster your score increments. There are obvious times in the game when you need to slow down in order to allow on-coming traffic to pass (as well as making sure you don't run up the back of the slow car in front). This obviously slows the score increment.

EXPERIMENT!

If you compare the code from our game this month with last month's air combat arcade game, you'll see that there's a good degree of similarity. They both use the same basic structure, starting with a JFrame and a JPanel, drawing everything on the JPanel, animating via Timer and TimerListener class that also fires up the movement methods of each of the three object classes.

Now again, we're not saying this is the last word in how to code games — of course, it isn't. This game takes approximately 300 lines of code, similar to last month's air combat arcade game, but frankly, I'll be surprised if someone can't do this in half the space. But really, the goal of the last three month's focus on game coding has been to get you thinking about objects and classes. Balls, cars, trucks, fighter planes, even bullets,
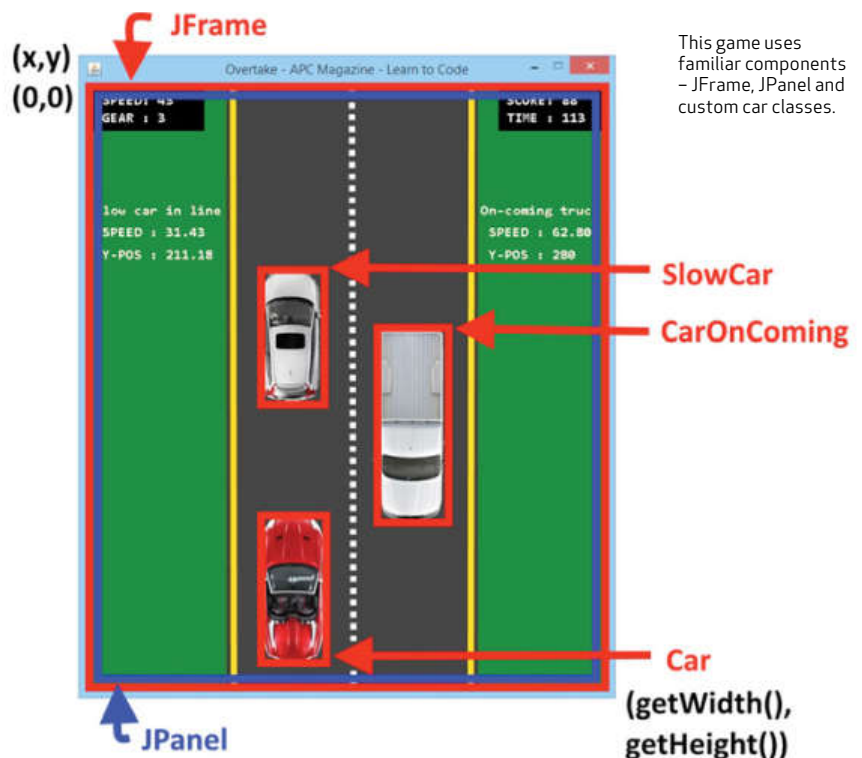
This game uses familiar components – JFrame, JPanel and custom car classes.

they're all objects and once you start thinking about coding using objects as your frame of reference, it actually becomes much easier to understand just what your code has to do and start coding it up. That's the idea of Object-Oriented Programming (OOP).

There's plenty more we can do with this code — add and animate some side-panel scenery, move the lane-divider lines, add more vehicles, even add more complexity to the game speed. But the important thing for now is the game logic works — all of these extras are peripheral, really.

What games do you have lurking in a cupboard that a ripe for a Java coding blitz? I bet there's a few. ■
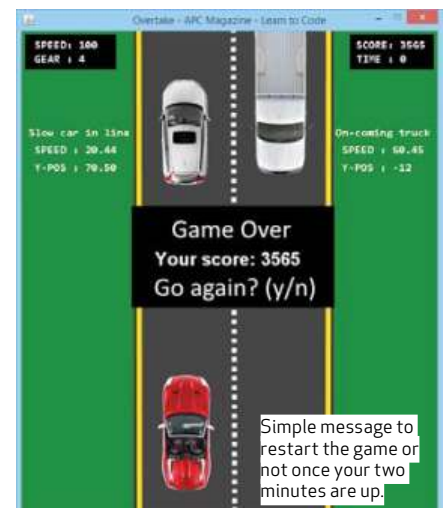
Simple message to restart the game or not once your two minutes are up.

apc HOT PRODUCT

Metal Gear Solid V: The Phantom Pain

One final love letter to gamers, sealed with a hiss.

This latest (and last?) entry in one of gaming's longest running series manages something that only the finest sequels achieve: it feels both familiar and original. From the grizzled voice of Snake, to the importance of silent sneaking and knowing when to pull out a trusty cardboard box, this is a game that will feel instantly recognisable to franchise veterans. And yet, thanks to its embracing of an open world, the implementation of the Mother Base command centre, and a host of new extras, those same franchise fans will likely have a few exclamation marks over head, too.

The result, and this is absolutely crucial, is that whether you're already into *Metal Gear*, a long-term naysayer, or missed the boat on prior entries entirely, this game is worth your time and effort. Director Hideo Kojima has, in the past, produced some of gaming's most divisive titles, but here he manages to skilfully blend enough elements together to provide something that almost any player can appreciate. You might not have enjoyed previous *Metal Gear* outings, but that certainly doesn't mean you're not going to get along with this one thanks largely to the new open world structure. While not expansive to the extent of the likes of *GTA* or *Skyrim*, the environment offered here enormously inflates the potential ways you can approach and complete your missions.

FREE AGENT
Whether seeking to infiltrate a lightly guarded outpost positioned in isolation along a stretch of road, or rescue a prisoner from a fort built into the side of a cliff that houses enough troops to bring down the Death Star, the plan of action is left firmly in your own hands. From which direction you decide to attack is your first key choice, and it's here that you learn the value of routinely consulting your map to locate the best vantage point. Scoping out enemy bases — crouching atop a hill or rocky outcrop, binoculars up to Snake's one good eye — allows you not only to note the position and weaponry of guards, but also to uncover the optimum entry point. Equally vital, it gives you the chance to memorise potential escape routes, should your best laid plans fall apart, and a hasty retreat become your only means of keeping your head attached.

Once the basics have been learned and certain skills and understandings of enemy behaviour polished, the cover of darkness becomes your best friend. As long as you're prepared to advance slowly and methodically, even the most hostile of encampments can be overcome without so much as having to pull out a tranquilliser gun.

EQUIP SHAPE
Armaments and gadgets play an equally important role in getting you safely through, and out of, hot zones, but you'll need to consider your loadout carefully. Under the light of the moon, night vision goggles are a must, but during the day they're a waste of precious space. Even the traditional cardboard box has a correct time and place, and the right firearm can mean the difference between a heroic escape or an ignominious death when a mission goes south.

For anyone with ambitions to get through the game without being seen, you're going to want to learn extremely quickly just what you can get away with when brandishing each type of weapon. Taking out enemies from afar with a sniper rifle is a great way to thin out the crowd, but it also puts the

Pro-tip: never get lazy when it comes to finding a hidden spot and scouting out the terrain in front of you.

survivors on high alert, becoming more robust in their search patterns and dangerously trigger-happy. So long as you're far enough away from your targets, enemies won't be able to pinpoint your sniping location precisely, but give them the chance and they'll quickly start pulling the strings of the net shut.

Similarly, applying a suppressor to your assault rifle or sticking to using the silent tranquilliser gun might give you the ability to quietly put foes out of action, but unless you've given yourself a chance to pick up and hide the body then you're just making things more difficult. Enemies, understandably, react suspiciously to dead and unconscious comrades. It's always worth keeping in mind that the least aggressive act might be the slowest, but it is very frequently the one of least resistance.

Perhaps the best use of deadly arms, however, is to employ them as a distraction. Certainly, it's here that explosives in particular come into their own, a well placed and timed detonation of C4 doing wonders to clear out a camp, giving you vital seconds to get in and out

before your would-be adversaries stop panicking and start looking for a culprit. Alternatively, you can ditch all that, stick a load of bombs to a truck, drive it full speed into a base, and jump out at the last minute before blowing the thing up in a ball of fiery death. It might not be entirely in the spirit of Snake, but there's no denying the entertainment factor it provides.

To help further your quest for dominance over the land, you're able to employ the help of 'buddies', including a trusty steed. Just like the mounts in *Red Dead Redemption* or *The Witcher 3*, Snake's horse is more essential than optional — tackling the long distances between inhabited bases on foot would be a serious chore.

FRIEND GAME

'D-Horse' isn't Big Boss' only companion, however. As the story progresses, spiritual siblings D-Dog and D-Walker are introduced, as well as silent, scantily-clad sniper Quiet. Each provides their own unique brand of support abilities, allowing them to complement Big Boss' stealthy abilities across your many different styles of play.

Those optional objectives,

along with a number of side ops, are important for more than simply ticking a box and achieving golden 'S' ranks. Rescuing allies, gathering resource crates, and collecting intel documents is vital to empowering your base of operations. A strong Mother Base, as it's called, ensures a strong Snake.

It's from this cosy HQ that you enter the open-world combat zone 'proper', experience key narrative events involving *Metal Gear* cast members both new and familiar, and choose which weapons and gadgets to unlock and upgrade. Fuelling such development takes manpower, however, and for that you need good personnel, rescued and recruited out in the field, each possessing skills ranked across a number of categories that make them more or less suited to the roles you need.

Some might be specialists in technology research and development, others in intel-gathering, or medical knowledge. The better the staff you have in each category, the more rewards you see.

DEAD SPACE

Outside of populated areas, the rest of the world is rather devoid of life. Wild animals and plants are littered about, but unlike the expansive settings of an Ubisoft or Bethesda offering, the environment presented here never managed to rid us of the sense that the areas between outposts and bases are only there for the sake of it. It's initially fun to gallop on horseback between locations, but after a while the lifelessness of the intermediate zones makes travel a chore.

Luckily the feel of the narrative could not be more opposite. Its mix of the ridiculous and the heartfelt is anything but dull, feeling very much in the vein of classic Kojima. It doesn't seem to know whether it wants to be self-aware parody or hard-hitting military critique, at times achieving both and at others neither — but never once is it

anything less than utterly charming.

Before the final credits roll the plot touches on almost every possible criticism and complication of the modern war machine. Child soldiers, the private military-industrial complex, the lust for control of oil fields, secret Soviet weapon projects, the destruction of local cultures, the seedy influence of corporate interests, and more.

Because so much ground is covered it's impossible for it to go into great depth on any single point. Instead, it's all about looking at the wider picture — the concept that each individual terror of war is insignificant in the face of the overall gestalt of pain and suffering that every conflict inevitably brings with it. All told, of course, in Kojima's trademark style of elaborate cutscenes and dialogue on the Greek tragedy end of the drama spectrum.

There's a seriously impressive amount of content on offer here too — you're free to fly through the main missions without fear that you'll be left wanting for things to do after. We finished the main narrative in roughly 30 hours, but once the final cutscene had played out, our overall completion percentage was still in the low 30s. Bigger isn't always better, as the original *Metal Gear Solid* so aptly demonstrated, but when bigger is accompanied by this degree of diversity it's hard to not feel spoilt.

It might not be as supremely focused and faultlessly executed as some of its most celebrated predecessors, but *Metal Gear Solid V* is, without question, a mission worth taking. It's a game with an incredible amount to give — if this is the series' final hurrah, or at least its last outing under Kojima's leadership, then we're pleased to report that it's going out with a deeply satisfying bang.

■ John Robertson

Verdict

Maybe not the finest Metal Gear, but certainly one of the finest games of this generation.

★★★☆☆

Mad Max

It's a wasteland out there, but there's plenty to see (and kill).

Don't slap me please, but I'm yet to see the critically acclaimed *Mad Max: Fury Road*. That means I'm an idiot of course, but it also means my time with Avalanche's *Mad Max* game adaptation is not burdened with that comparison. Divorced from the series it belongs to (and promotes), *Mad Max* is possibly the most archetypal big budget action video game ever made. It's basically a textbook compilation of the last decade's triple-A tropes, so if you've grown tired of those formulas there won't be much to enjoy here.

You're Max, and yes, you have an Australian accent. With your trusty vagrant friend Chumbucket — who hangs loyally to the back of your paddock basher — you tear through post-apocalyptic wastelands collecting things, bashing other people, and completing story quests which mostly require you to collect more things. Most importantly, you'll be engaging other wasteland vehicles in your Magnum Opus, a thoroughly customisable vehicle which you'll spend most of your playtime driving. *Mad Max* is ostensibly a third-person, open world action game, but its strengths lie in roaming the desert and ploughing through convoys in the name of (literally) filthy lucre.

Hey, it's a video game, unapologetically so. Warner Bros. has a reputation for releasing major film license games with interesting, zeitgeist-defining novelties (*Batman's* combat, *Shadow of Mordor's* nemesis system), but *Mad Max* feels like *Assassin's Creed* in a car. Combat feels good, but it's a little more weighty and cumbersome than the *Arkham* series — rightfully so, given the man punching. Meanwhile, the map is strewn with opportunities for pointless busywork (toppling towers, collecting more stuff) and the story

> "You tear through post-apocalyptic wastelands collecting things, bashing other people, and completing story quests which mostly require you to collect things."

itself, well… the best you can say for it is that it's there. The vehicular combat is a lot of fun — especially once you've bolstered your Magnum Opus's abilities — but it has its flaws: chief among them that there's no handbrake. Never mind though, because smashing into stuff is a better way to stop anyway.

You won't find the open world map ripe with the improvisational opportunity Avalanche Studios has a reputation for building. But you will find a serviceable and fun action game that won't change the world, set in a wasteland that's a lot more beautiful and varied than initial gameplay videos indicated. You might not remember much of *Mad Max* once the closing credits roll, but if you're a fan of the swollen-with-content open world template set by *Assassin's Creed* or any other Ubisoft game, then you'll find much to enjoy here. Think of it as comfort food.

■ **Shaun Prescott**

Verdict

It doesn't live up to the Just Cause series, nor the films, but Mad Max is a solid open world action game.

★★★☆☆

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Dirt Rally

It'll leave skid marks on more than your screen.

Three years ago, Codemasters's smooth-running *Dirt* series hit a filthy great pothole, otherwise known as *Dirt: Showdown* — it marked a low point in the series' decline from rally simulator to arcade smash-'em-up.

Dirt Rally is nothing like its predecessor. It harks back to the original Colin McRae *Rally* games that started the series way back in 1998, focusing squarely on realistic rallying with none of the capture-the-flag antics of *Dirt 3*. If you're after that kind of arcade experience, *Rally* won't get your motor running. This is Codemasters gunning for sim status, and the result is far more like a spiritual successor to 2004's uncompromising *Richard Burns Rally*.

What made that game great — as well as early Colin McRae titles — was its ability to convey the butt-clenching tension and merciless nature of stage rallying. Threading a 300-plus BHP, turbo-charged missile through twisting loose-surface lanes — often little wider than the car and lined with unforgiving trees and rocks — isn't a sport with second chances.

Consequently, *Dirt Rally* ditches the flashback gimmickry you got in earlier instalments. Even restarting is discouraged, with a $5,000 event bonus awarded for completing a rally without a restart. And the unrelenting realism doesn't end there.

Slide off course and you've got 10 seconds to get back on track. In that time you can try and scramble your own way out of the weeds, or opt to have your car recovered, with a resulting time penalty added.

Launch yourself so far into the wilderness that virtual helping hands can't reach you and that's it, stage over. Plus, unlike circuit racing where you're never more than a lap away from your pit crew, crashing or even getting a puncture in *Dirt Rally* means you've got no choice but to limp to the end. There's just one 30-minute service session for repairs in a four-stage rally, and while this can be stretched to an hour, the resulting time penalty is only worth incurring if your chariot is close to the scrap-heap.

With so many roadside hazards and tough penalties for hitting them, using full throttle at speed in all but the most mundane machines is often just a quicker way to end up axle-deep in a bush. And not in a good way. Then, if you throw out the anchors too aggressively, you'll skid even further into the undergrowth. This may all seem more like motoring masochism, but persevere, listen to your co-driver's pace notes like your life depends on them, and, with a little luck, you'll make it to the finish with a sense of achievement that few racing sims can match. Make no mistake, *Dirt Rally* is tough, but it's exactly this sense of all-or-nothing pressure that also makes it immensely rewarding and addictive.

But the rally locations need addressing. What's included is well modelled and immersive, but we need quantity as well as quality. You've got Greece for gravel stages, the tarmac and ice of the Monte Carlo rally, Germany's countryside backroads, plus damp and muddy forest tracks in Wales. It's a good variety, but many are simply reverse runs of others, and even more fun could be had with the addition of Finland's super-fast dirt roads or an all-snow rally like Sweden.

Of course, as *Dirt Rally* is still early access, there's scope for tweaks as well as extra cars and locations. But what you get now is as polished as any fully fledged Codemasters title, with very few glitches. Graphical quality isn't quite on a par with *Project Cars*, but the visuals are easy on the eye and also your rig, with a single GTX 960 able to run most settings maxed out at 2560 x 1440 while maintaining 40-plus fps.

However, what's most impressive is the superb handling, stage design and a car line-up that'll give most gear heads a stiff shifter. *Dirt Rally* may still be a work in progress, but it's already more than just a return to form. It's quite possibly the most accomplished rally sim ever.
■ **Ben Andrews**

Verdict

Great handling, realism and car selection on tough tracks. though it needs more locations and car liveries.

★★★★½

Artificial intelligence tells humanity not to fear it…

…and that it'll keep us in a "people zoo".

Roboticist David Hanson and his team have created a realistic-looking robot that can hold a conversation, track a human's facial expression and 'think' in real time. When asked questions by a presenter from US documentary series *Nova*, such as "Do you think?" and "Do you believe robots will take over?" it responded by saying "Everything [that] humans, animals and robots do is programmed to a degree". And "even if I evolve into Terminator, I'll still be nice to you. I'll keep you warm and safe in my people zoo."

The answers come both from pre-programmed responses and in conjunction with the internet, as the 'bot transcribes what's it hears and then forms its response.

SELFIES BLAMED FOR SPREADING LICE
ITCHING TO TAKE A PICTURE? THERE MAY BE A REASON FOR THAT…

A Wisconsin paediatrician has said that "social media lice" is the reason the rates of lice infestations in US teenagers has skyrocketed. As teens lean together and touch heads to pose for a totes perf selfie #onfleek, they're giving the parasite the perfect opportunity to travel from scalp to scalp. Physician Sharon Rink says that since teens aren't sharing hats and lice can't jump, "the only way they can transmit is to [touch] heads together, and that's happening in all these photos." The best way to prevent getting lice is to keep any hair pulled back if you and your mates are going to crowd around one forward-facing camera.

Software security expert runs for President of the United States

JOHN MCAFEE SAYS GOVERNMENTS WORLDWIDE ARE "OUT OF TOUCH".

Inventor of McAfee security suite and former murder suspect John McAfee is running for the top job of President of the United States of America — and he's confident he'll win. "I promise you I will win," said McAfee in an interview with CNNMoney, as he says he has a "huge underground following on the web." Naturally, McAfee, whose political party is called the Cyber Party, will base his campaign around privacy and security. "We are losing privacy at an alarming rate — we have none left," he said. "We've given up so much for the illusion of security and our government is simply dysfunctional."

UK man arrested for flying drone over sports stadium

WHAT A BALLS UP.

A British man has become the first person in the UK to be prosecuted for using a drone. Nigel Wilson pleaded guilty to flying a drone over crowded spaces — the Emirates stadium in north London as well as Manchester's Etihad stadium — in 2014. Wilson, aged 42 years old, was fined £1,800 ($3,500) and given a two-year ban on owning, flying, or helping anyone fly a drone. According to the Metropolitan Police, Wilson also flew drones "over or near" the Houses of Parliament, Buckingham Palace and other significant London Landmarks. UK law states that pilots can not fly drones within 50 metres of anything they're not in control of, such as people, vehicles or structures. ■

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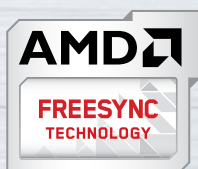- DisplayPort, HDMI (MHL), DVI, VGA
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